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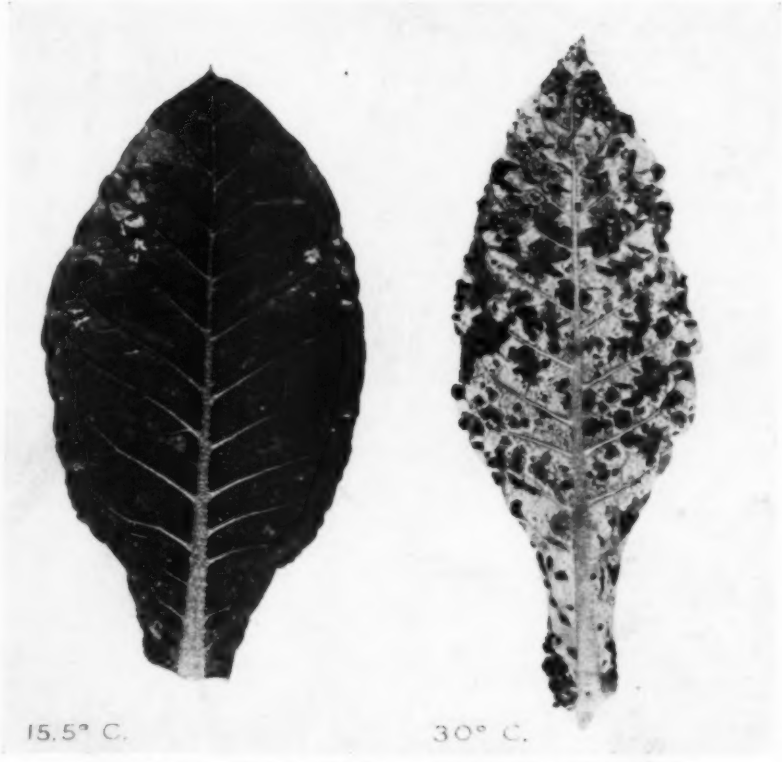

EFFECT OF TEMPERATURE ON EXPRESSION OF YELLOW TOBACCO MOSAIC

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A Probable New Sex-Linked Dominant in Man

Brainy People Have Good Characters

Identical Twinning in Sheep

The "Hereford" Hog

A Genetic Glossary

VOLUME 28 FEBRUARY, 1937 NUMBER 2

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks

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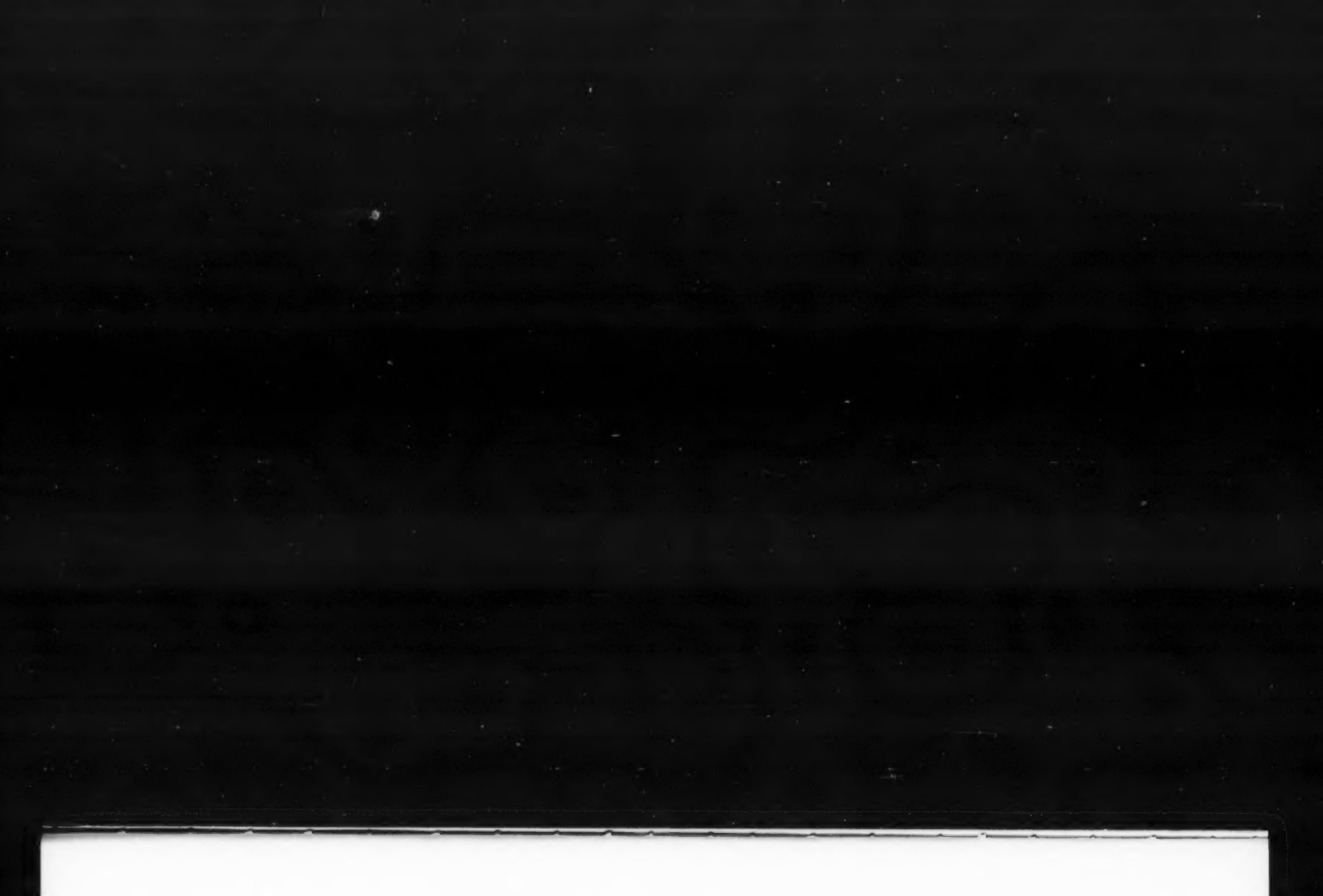

The

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Vol. XXVIII FEBRUARY, 1937 No. 2

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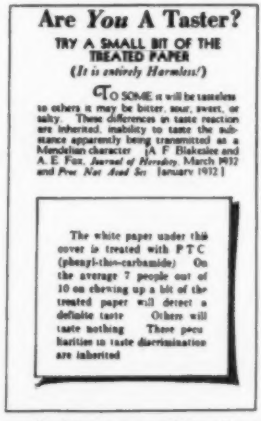
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Last year the "Taster test" served as an introduction to human genetic differences in many classrooms. The test is so easily made with the treated paper, and arouses such great interest that it appears to have a definite place in group demonstrations of such differences. These leaflets, size 3⅜" by 5½", are available in quantities for those who wish to use them for classroom or lecture purposes. On the back is printed an outline 4-generation pedigree chart. Sample on request. Prices: 10 for 25c; 50 for $1.00.

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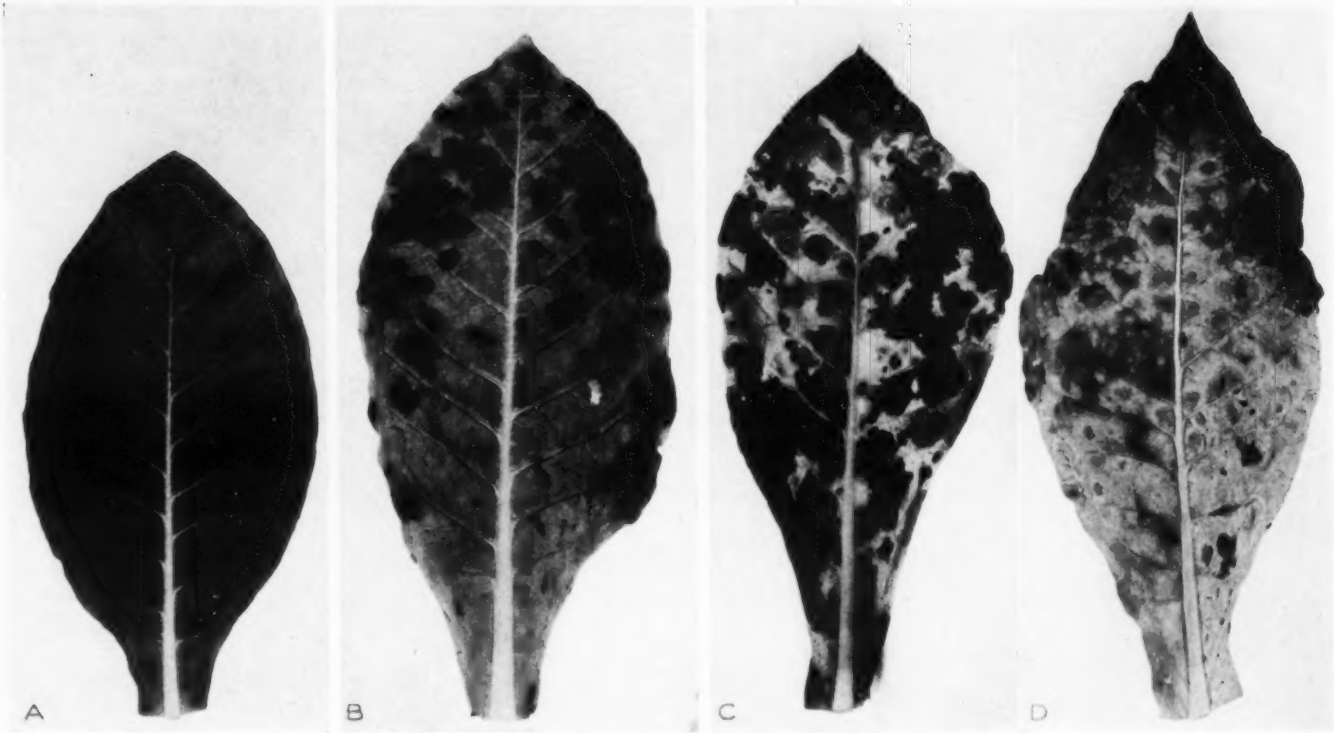

COMMON MOSAIC AND A MUTANT MOSAIC IN TOBACCO

Frontispiece

A—A leaf from a healthy plant. *B*—A leaf showing common mosaic and one yellow-mosaic spot, on the right. The normal tissue is dark. The tissue affected by the mosaic is light green, and the mutant spot is bright yellow. *C-D*—Leaves showing a yellow-mosaic the virus of which was isolated from a yellow spot such as the one illustrated in *B*. The spontaneous change in the mosaic is maintained in transfers to other plants, showing that a permanent alteration has taken place in the nature of the virus. These sudden changes, which are of rather frequent occurrence, closely parallel mutations in animals and plants.

VIRUS MUTATION AND THE GENE CONCEPT*

H. H. McKinney

Division of Cereal Crops and Diseases, United States Department of Agriculture

FOR many years biologists and, more recently, chemists have been searching for facts which would settle beyond doubt the precise nature of the viruses, those ultramicroscopic filterable entities causing many different types of infectious diseases in plants, animals and man. In plants alone there are many distinct groups of virus diseases. Within certain of these groups, possibly all of them, there are sub-groups and some of these sub-groups likewise divide into smaller groups which have been referred to as strains. The mosaics constitute the largest known group of plant virus diseases. There are many different mosaics and some of these comprise several strains which are considered to represent mutations.[7]

Certain published and unpublished evidence as well as views concerning the important biological and chemical aspects of the virus of tobacco common mosaic are presented, and there is a brief discussion of some of the difficulties which are encountered when an attempt is made to harmonize certain of the present chemical and biological concepts relating to the nature of this virus. It is not necessary to summarize the earlier literature on the nature of the virus in more than a cursory manner since this has been done recently by Wolf.[13] In order to reduce the literature list in the present paper some of the literature referred to is not cited; however, most of the papers can be located from the comprehensive lists in Wolf's book.[13]

Views on the nature of the virus of tobacco common mosaic

The virus has been variously considered to be: (1) a microscopic organism, (2) an ultramicroscopic organism, (3) a connecting link between a strictly chemical system and living cells, (4) an enzyme, and (5) a protein. The one fact which has led tc the belief that the virus represents a form of life is that it regenerates indefinitely in series transfers in living susceptible plants. However, this evidence has not been sufficient to convince all workers that the virus is an organism.

In 1899 Woods considered the virus to be either an oxidase or a peroxidase and several later workers advanced the enzyme theory.

In 1904, Moore[8] put forth the idea that the regeneration of viruses can be explained on the basis of an autocatalytic process, the mechanism of which he considered to be comparable to that occurring in the oxidation of copper by nitric acid in the presence of nitrous acid or a nitrite. A year later Hunger considered the tobacco-mosaic virus to be physiologically autocatalytic.

After carrying out many experiments with the virus of tobacco common mosaic, Allard came to the conclusion that the virus is not an oxidyzing enzyme, and he was inclined to the belief that it is an ultramicroscopic organism. This view was generally accepted.

Several investigators have entertained the view that viruses are intermediate between the strictly non-living chemical system and living cells, and Davis[2] proposed the name "vitamol" for such a hypothetical entity.

Duggar and Karrar[3] in 1923 suggested that the virus of common mo-

*This paper, in more detailed form, was approved by the Chief of the Bureau of Plant Industry, November 3, 1936.

saic may represent "—a gene perhaps, which has, so to speak, revolted from the shackles of coordination—." However, no direct evidence was presented in support of this view.

During the past ten years there has been a definite trend in the development of new methods for studying the plant viruses and there has been a marked increase in the use of physical and chemical methods. As a result it has been amply demonstrated that the virus of tobacco common mosaic can be concentrated in certain of the precipitates and crystals obtained from the diseased plant extracts.

At the Congress of International Plant Sciences in 1926 Duggar announced that the virus is carried down in the precipitate in mosaic tobacco juice after adding calcium chloride. This announcement was not published, however, until 1929.

In 1927, the writer[6] reported results of quantitative virus tests which show that the greatest portion of the virus in an extract goes down with proteins which are coagulated near 65°C. These precipitates when tested were about 20 times more active than the filtrates which passed through a soft filter paper. Many tests were made on the solid and the supernatant fractions obtained by means of a super-centrifuge and it was found that the bulk of the virus went with certain precipates. During the same year and later, Brewer, et al., reported that they could obtain a highly purified water suspension of the virus by means of filters, aluminum jel and the supercentrifuge. Vinson during the same year concentrated the virus in protein precipitates by means of acetone, absolute alcohol, ammonium sulphate and Safranine-O.

Vinson and his coworkers[12] conducted several pieces of research which led them to conclude that the virus is chemical in nature and not a living organism. Barton-Wright and McBain, in 1933, repeated the work of Vinson and Petre and they concluded that the protein fraction plays no part in infection. They isolated a white crystalline compound, containing no nitrogen, which induced infection in all of the plants which were inoculated.

Caldwell, in 1934, working with a virus which is closely similar to that of tobacco common mosaic repeated the experiments of Barton-Wright and McBain and he concludes that their white crystals represented part of the reagents used in the elution of the virus before the reprecipitation with acetone. He concludes further that the phosphate crystals form around the infectious particles and that the virus "—is either protein in nature or is closely adsorbed to the protein, that on any alteration of the physical state of the juice, the virus reacts as does the protein." Vinson also repeated the work of Barton-Wright and McBain and he states that his preparations which contain the large quantities of virus also contain nitrogen. He also obtained in other work several crystalline products; one which he recrystallized three times contained detectable amounts of virus but no Kjeldahl nitrogen. Because the virus test is more sensitive than the nitrogen test it was not possible to detect the small trace of nitrogen thought to be present.

Vinson's methods eventually enabled him and his associates to obtain a nitrogen fraction containing much active virus, and there seems to be little reason to doubt from the reports that it represented a rather high state of purity. With certain modifications of Vinson's methods, Stanley[9,10] also obtained a protein of high virus concentration which he was able to crystallize. He has obtained large quantities of crystals possessing an exceedingly high virus activity as determined by the number of necrotic lesions produced on plants inoculated with highly dilute solutions. He considers these crystals to be a pure protein or to consist of a solid solution of proteins which increases in the plant by means somewhat comparable to the generation of trypsin from an inactive precursor.

Later Stanley[11] reported that treat-

ments of the active virus crystals with hydrogen peroxide, formaldehyde, nitrous acid or ultra-violet light, produced inactive native proteins not capable of inducing the disease symptoms but which retain their crystal characteristics and certain other chemical characteristics, together with their original serological characteristics. Chester[1] reports having tested Stanley's virus crystals by serological methods and he concludes that they contain a contaminating protein serologically allied or identified with protein present in the healthy plant. Whether this contaminating protein is the same as that which was inactivated by Stanley or represents still another protein is uncertain.

Virus mutation

When evaluating the several theories regarding the nature of the virus it is necessary to bear in mind that we are dealing with an entity which is not fixed in all of its measurable characteristics.[7] Different collections of virus of common mosaic obtained from widely separated regions do not always induce identical symptoms in tobacco, though the symptoms are very similar. Furthermore, some of the collections which were indistinguishable on tobacco were distinguishable on *Nicotiana glauca* R. Grah. While these viruses tend to regenerate true to their respective types over long periods, they do give rise, in occasional local zones in the infected plant, to aberrant viruses (Frontispiece) which when isolated and purified are found to induce symptoms decidedly distinct from those induced by the typical or primary virus. Furthermore, some of the aberrant viruses in turn give rise to other aberrant types and those observed by the writer have also arisen in occasional local zones in the infected plants and have not involved more than a very small proportion of the total virus in the plants. Some of the aberrant types reported by Jensen,[5] however, seem to involve a considerable portion of tip leaves. The writer[7] interprets this phenomenon as mutation because all of the evidence indicates that the changes do not represent contaminations or mere transitory fluctuations.

When inoculated into tobacco, virus mutants show distinct differences with respect to their ability to invade[5] and to disturb the plastid pigment mechanism at ordinary temperatures. Some of them invade the plant but produce little or no observable disturbance of the chlorophyll mechanism.[4] Others which the writer has not yet described induce a very mild disturbance as evidenced by a light-green mottling which is less intense than that induced by the primary virus from which they mutated, whereas others induce a yellowish-green mottling and still others upset the chlorophyll mechanism to such an extent that a large portion of the foliage exhibits a light yellow to almost white mottling.

The effect of temperature on the rate and type of mutation

The writer[7] found that yellow-mosaic mutants appeared much sooner in tobacco plants when cultured at high growing temperatures. Subsequent tests show that the yellow mutation spots are rare at temperatures near 15°C. At 21 to 26°C. they were slow to appear and relatively few in number on each plant, whereas near 32°C. they appeared more quickly and they were more numerous, and at temperatures near 36°C. they became less numerous or did not appear at all during the tests.

James Johnson has reported that the symptoms of common mosaic are wholly or partially masked in tobacco grown in culture chambers at 35° to 37°C. He considers further that the virus from such plants has become attenuated, inducing very mild or no mottling symptoms in the plants. Holmes isolated a masked mosaic virus which apparently represents a sub-mutant two steps removed from the primary virus of common mosaic. The appearance of this strain was favored by a temperature of 34.6°C., and subsequently several mutants were obtained from it

A VIRUS RESISTANCE ALTERED BY TEMPERATURE

Figure 1

Pepper plants (*Capsicum fruitescens* L.), showing effect of temperature in altering virus reactions. *A*—Healthy plant, not inoculated, illustrating the appearance of plants cultured near 22.5°C. and near 31.5°C. during the early stages of growth. *B* and *C*—All leaves on the main stems were wiped with virus of tobacco common mosaic, after which plant *B* was kept near 22.5°C. and plant *C* near 31.5°C. The inoculated leaves of both plants abscissed after they developed symptoms. No detectable virus entered the stem of plant *B* but virus did enter the stem of plant *C*, inducing necrosis and death of a large portion of the stem. The virus was recovered from this stem.

Working in plant-culture chambers which receive full sunlight, the writer found that the mottling of common mosaic on tobacco is quite evident and not masked at 35° to 37°C. Virus was isolated from 100 uniformly distributed zones (1 mm. in diameter) in the leaves of two plants growing near 36.1°C., each virus sample was inoculated into a young tobacco plant and all plants were cultured near 23°C. Of these plants, 12 remained healthy, 75 developed typical symptoms of common mosaic, and 13 developed a mild light-green mosaic, some of which now give evidence of yielding yellow-mosaic mutants. Plants with common mosaic and growing near 23°C. have not yielded these mild-mosaic viruses in the writer's tests. These results suggest that mild-mosaic viruses arise in certain zones in the plant as is the case with the yellow-mosaic viruses and they show that the bulk of the original or primary virus remained essentially unchanged so far as can be determined from the mosaic symptoms on tobacco. Thus it appears that certain types of so-called attenuation may result from mutations.

There is a possibility that reverse mutations occur in virus strains, but so far as the writer knows, there is no positive evidence that a known mutant has given rise to the primary virus of common mosaic through reverse mutation.

Differentiation of virus mutants dependent on the environment as well as on the nature of test plant

Nearly 100 mutants, reported and unreported, have been isolated from the common mosaic, but the exact number of these which constitute distinct strains is uncertain because many of the comparisons in test plants apparently have not been made under sufficiently controlled environmental conditions. Some of the strains of yellow mosaic induce essentially identical yellow mottling symptoms in tobacco at

temperatures near 21° to 24°C., but as reported previously,[7] two strains can be differentiated in tobacco grown at temperatures near 15°C, since at this temperature it is very evident to the eye that one of the viruses is more effective than the other in reducing the chlorophyll in the mottled areas.

In certain test plants other than tobacco some virus strains are capable of inducing local necrotic lesions, local chlorotic spots, and systematic symptoms, depending on the environment. The writer has found that some of these plants, a perennial pepper (*Capsicum frutescens L.*), for example, when cultured at temperatures near 23°C. develop local necrotic lesions on mature and nearly mature leaves when wiped with the primary virus of common mosaic and these leaves eventually abscisss. No signs of systemic symptoms of any kind appear in the rest of the plant and all tests have failed to reveal the presence of virus in the stem or unwiped leaves, and the plant may be considered immune to systemic infection by this virus. However, this pepper is not immune to systemic infection in a strict genetic sense because there are factors for systemic infection present as revealed by tests carried out during the summer near 32°C., a temperature which is considerably below the lethal temperature for the healthy plant. Here the picture is quite different inasmuch as local chlorotic spots develop on the wiped leaves and the virus invades the stem before all of the wiped leaves absciss. Necrosis develops in the stem and some of the leaves, mottling symptoms appear on some of the young leaves and ultimately a large portion of the plant or the entire plant dies, as illustrated in Figure 1. The virus from leaves attached to the woody portions of branches and stems does not invade the stem with as great facility as that from leaves attached to succulent portions.

With the possible exception of slight differences in temperature range, the observations described for pepper apply in a general way to *Nicotiana sylvestris* Spegaz. and Comes when the young leaves are wiped with the virus of type *A* yellow mosaic, a mutant[7] from the virus of common mosaic. When mature or nearly mature leaves are wiped with the inoculum and the plants are cultured at the high temperatures the local infections tend to appear as chlorotic spots, and systemic mottling and systemic necrosis appear later than is the case when the young leaves are inoculated. The inoculated leaves of this species do not absciss. Certain of the symptoms induced by this virus on *N. sylvestris* at temperatures near 32°C. and above are also induced by certain other strains of yellow-mosaic virus but at lower temperatures.

It is evident from the results of many tests that temperature must be regarded as an important factor in the problem of virus-strain differentiation and description. Furthermore, genetic segregation studies dealing with certain virus-symptom characters as well as with resistance should be conducted over a range of suitable temperatures, and symptom characters should be carefully defined, otherwise segregation ratios and final interpretations will be open to question. Some of the virus strains which appear to be identical can be differentiated on a single plant species or variety when the tests are conducted at suitable temperatures. In some instances this method will reduce the work involved in a search for suitable test plants.

Light and other factors influence the expression of symptoms but these have received less study.

Mutants and sub-mutants tend to show certain relationships

In contrast with the marked difference in the ability of virus mutants to disturb the plastid pigment mechanism and to invade certain species and certain tissues of a given species, it is noteworthy that some of the characteristics which are common to the primary virus change much less readily than others. The high thermal inactivation

point, the ability of the virus to retain a comparatively high activity level in dry tissue and in plant extracts when stored at laboratory temperatures and the antigenic properties are characteristics which for the most part seem to show relatively little change. It appears that certain characteristics which are unique to some mutants tend to persist in subsequent mutants from these. This is indicated in the studies of Holmes[4] in which he found that most of the yellow-type mutants from a strongly systemic strain of distorting tobacco-mosaic virus were also strongly systemic. A few were weakly systemic and a few were not systemic in tobacco. On the other hand, none of the yellow-type mutants from a weakly systemic masked strain were strongly systemic but some were weakly systemic and others were not systemic in tobacco.

In view of the evidence that active virus is not a constituent of normal susceptible tobacco plants, that the virus regenerates true to a measurable type, that it mutates, that the mutants and sub-mutants also regenerate true to their respective types and manifest more or less orderly relationships to each other, it is difficult to believe that the primary virus and its many strains represent closely related enzymes of the ordinary sorts. There seems to be no evidence at present which indicates that any of the closely similar enzymes in plants or animals represent aberrant types—mutants—arising spontaneously from a given enzyme, proenzyme or activator. Furthermore, if virus generation is accomplished through autocatalysis, it appears that the precise mechanism of the process differs from that obtaining in the generation of trypsin from the inactive chemical precursor.[10] If a precursor or provirus is present in healthy tobacco plants, it appears that this possesses an unprecedented capacity for reacting differently to the many different activators—strains of virus in this case—or that there are separate precursors for the separate activators, otherwise the many virus strains could not be regenerated through long series of subinoculations.

It is possible that virus generation involves some unique system of precursors. However, the evidence now available tends to favor the view that the virus and its mutants embrace the essential elements of lineage or inheritance. This view is based on the evidence that the virus, its mutants and sub-mutants, regenerate true to measurable types and because the mutants and sub-mutants tend to retain certain characters of the primary virus, and the sub-mutants tend to retain certain characters of the strains from which derived. It would seem that these combined features and not Mendelian segregation must serve as the basic test for inheritance, otherwise we would be forced to take the absurd position that inheritance does not exist in the bacteria and other asexual organisms.

It is possible that the virus represents a filterable form of some larger organism, or it may represent a degenerated organism which has retrogressed by a series of mutations to a stage where a few genes or perhaps a single gene remains to perpetuate as virus. However, it does not seem necessary to assume that the virus represents a stage in a degeneration process, since it may represent a stage in a progressively complex evolutionary development from molecules, and it may possess a simple metabolism. In any case, the primary virus and its mutants doubtless reflect a series of closely related compounds which function essentially as genes. The several characters of a given virus may reflect properties of a single compound and changes in any of these characters—mutations—may reflect alterations in this compound.

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THE "GENETIC FURORE" IN USSR

Since my recent letter, I had the opportunity to read over carefully the Soviet press, and particularly the daily *Socialist Agriculture*, and the following brief summary will give you some idea how important this matter is in the Soviet Union.

The Fourth session of Lenin's Academy of Agricultural Sciences, devoted to "Plant and Animal Breeding" opened on December 20 and continued day and night until December 27. Every day for 10 days *The Socialist Agriculture* gave complete reports of the proceedings. The principal address by Prof. N. I. Vavilov was given in full. Lysenko's reply was also given in full. These two addresses occupied nine columns of the total of 24 columns of the issue of December 24. Over 150 persons took part in discussions, and there were over 3,000 persons present of whom 450 were specially invited, and most of these were connected with genetics, or plant and animal breeding. Among other scientific workers who delivered papers were: Acad. G. K. Meister, Acad. B. M. Zavadovsky, Acad. A. S. Serebrovsky, Acad. P. I. Lisitzin, Dr. G. G. Meller, and many others. Photographs of individuals and groups of men appeared every day.

Lysenko and his associates made an attack on "formal geniticists." Lysenko claims that plants degenerate, and by crossing of plants of the same variety they regenerate—harden, and improve in yield, etc. Lysenko also claims he can transform winter into spring plants, that is, he can "reeducate or re-direct" plants. Vavilov and his associates while admitting the excellent results obtained by Lysenko's vernalization (yarovization) methods, deny mutability and degeneration of varieties.

Prof. Meister, of Saratov Plant Breeding Institute, who by the way visits U. S. A. this summer and fall, tried to bring "peace in the family" by suggesting further experimentation, and cautioned both sides against making hasty conclusions.

On reading the above discussions and debates, one can not help but come to the conclusion that the main reason for postponing the International Genetic Congress was due to this lack of unanimity among Soviet geneticists, and plant and animal breeders.

Academician Vavilov's telegram to the New York *Times*, denying his arrest, and particularly protesting against *Times* and *Science Service* allegations against freedom of Soviet science was printed not only in the *Izvestia* (News) under the date of December 22, 1936, but also appeared in a prominent place in *Socialist Agriculture* of December 23, and again in the issue of December 24 there was a dispatch from New York announcing apology of New York *Times* and *Science Service*.

J. W. PINCUS.

A PROBABLE NEW SEX-LINKED DOMINANT IN MAN

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A NUMBER of pedigrees have been published in which defective enamel of the human teeth turns out to be a dominant character. In none of them does it skip a generation, so the manifestation in heterozygotes is complete. The defect varies from a slight irregularity causing brownness of the teeth to an absence so complete that the teeth are worn down to the gums early in life. Since the type of abnormality differs in different pedigrees, and is fairly constant within a given pedigree, it is clear that we are concerned with several different genes, and not with a single gene whose expression is affected by modifiers.

The majority of these pedigrees show nothing abnormal, but one, compiled by Bampton[1] and reproduced in Figure 2, presents a striking irregularity. Individual III_1 transmitted the abnormality, in this case brownness of the teeth, to all of his eight daughters and to none of his four sons. On the other hand, the mothers transmitted it to children of both sexes.

Clearly this fact can be explained if the dominant gene is carried by the *X* chromosome. An affected parent will transmit it to half his or her children. But while a mother will hand it down equally to sons and daughters, a father can only derive it from his mother, and must transmit it to all his daughters and none of his sons.

In the pedigree it is not certain whether II_1 was an only child; III_1 was the eldest of several children, but nothing is known as to the teeth of the sibs. Not all the members of generation IV were personally examined by Bampton; however, he gives their ages, and there is no reason to doubt his account. V_6 was only two years old, and might have developed the abnormality later. V_{7-9} were the original patients from whom the investigation started.

The deciduous teeth might be brown or white on eruption. If white they generally, but not always, developed pigment later. The permanent teeth were always brown on eruption, and darker than the milk teeth. The enamel was not very dense—not soft yet not quite normal—and had a dull appearance, rather rough and inclined to be pitted.

It is of course possible that the extraordinary distribution in generation IV was due to chance. The probability is however 2^{-12} or 1/4096. This is small enough to make the pedigree well worthy of publication, but large enough to leave open the possibility that we are dealing with a fantastic run of luck.

X-Y Crossovers

Besides complete sex-linkage of the ordinary type another explanation is possible. Haldane[4] recently described a new type of human inheritance. He claimed that in a number of diseases the genes concerned are incompletely sex-linked. That is to say they are located in that part of the sex chromosomes which is common to the *X* and *Y*, and may occasionally cross over from one to the other. The diseases so determined are complete color-blindness, xeroderma pigmentosum, Oguchi's disease, recessive epidermolysis bullosa dystrophica, and some cases both of dominant and recessive retinitis pigmentosa.

If a man inherits such a gene from his mother, it is in his *X* chromosome. Such men will hand down the disease to most if not all of their daughters, and to a few of their sons. On the

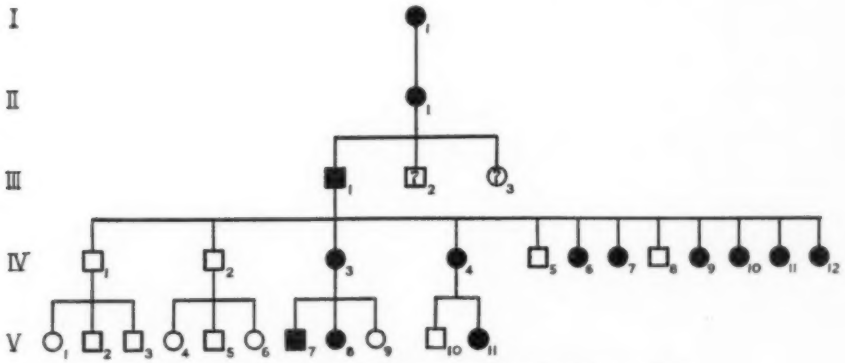

Figure 2

The sex distribution of the defect in Generation IV is what would be expected if a dominant sex-linked gene were involved, though there is a remote possibility (odds 1 to 4096) that this limiting of the defect to females might be due to chance distribution of an autosomal (non-sex-linked) gene.

other hand, men who receive the gene from their fathers hand it on mainly to their sons. If the gene in Bampton's pedigree crossed over between the *X* and *Y* chromosomes in 5 per cent or 10 per cent of cases, a family such as generation IV would be frequently produced.

There are four other pedigrees of hereditary brown teeth in which affected men, whose affected parents are known, have had children, namely those of Clark and Clark,[2] Moore,[5], Sinha[7] and Turner.[8] Among the 41 children of such affected fathers in these pedigrees there were 23 cross-overs on this hypothesis, and the lowest percentage of crossing-over was 40. On the other hand, Bampton's pedigree shows no cross-overs out of 12. Thus in the remaining pedigrees there is no suggestion of sex-linkage, partial or complete. This is not surprising; for in some, at least, of these pedigrees the enamel was much more defective than in Bampton's and we are clearly dealing with different genes.

Y-Chromosome Inheritance

There are several cases in the literature of characters apparently due to dominant genes in the human *Y* chromosome. Some of these are perhaps due to translocations. A few of the normally recessive sex-linked genes, such as that for Leber's disease (optic atrophy) sometimes show up in heterozygous women. The only case known to me which is probably due to a dominant gene carried by the *X* chromosome is Siemens'[7] case of Keratosis follicularis spinulosa cum ophiasi, an affection of the hair follicles and sebaceous and sweat-glands of the head and neck, sometimes also affecting the cornea, palms and soles. Here three affected fathers begot five affected daughters and seven normal sons, besides one daughter and two sons who died before the disease could have developed. The probability that this distribution could be due to chance is exactly the same as in Bampton's case.

Siemens' evidence for sex-linkage is, however, slightly better than my own, since heterozygous females never showed the disease in its severest form. This is analogous to the behavior of the sex-linked dominant Bar in *Drosophila melanogaster*, which affects the eyes less in heterozygous females than in males. An incompletely sex-linked gene should affect both sexes equally,

like an autosomal gene. The fact that males and females are equally affected is not, however, evidential against complete sex linkage. Thus the dominant gene for Barred feathers in poultry has the same effect in females, which necessarily carry only one gene, and in heterozygous males, whilst in homozygous males the effect is considerably larger. In Bampton's case therefore we cannot decide between complete and incomplete sex linkage.

I have to thank Dr. E. A. Cockayne for most generously allowing me access to the unpublished notes for his book[3] on inherited abnormalities of the skin, among which I found an abstract of this case.

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CURRICULA AND THE BIRTH RATE

Revision of Academic Courses Not Likely to Increase College Graduates' Progeny

"Data obtained from an equal number of married college women and also from their female relatives and friends of the same social class who had had no college education indicates that while those of the former group had only 1.48 children per marriage as against 1.77 children of the latter, the non-college women were on the average three years older and had had 4.4 more years of married life at the time the study was made. Despite the fact that four years of higher education raised the age of marriage of college women nearly a year and a half, they had borne an average of 0.164 children per year as against 0.132 for the non-college group. The greater interest of college women in professional employments probably operates to increase the number of college wives engaging in gainful occupations, which reacts dysgenically on the birth-rate."

* * *

With regard to the second question raised at the beginning of this paper—namely, Will the introduction of sound courses in eugenics, home-making and the social importance of the family into the curricula of colleges educating women have a beneficial effect on the size of family of college graduates?—it may be said at once that no valid answer can yet be given. No nation-wide investigation of the curricula offerings in these subjects has yet been made. An examination of the most recent catalogues of ten outstanding women's colleges in the United States disclosed that only one (Smith) offers a course entitled "Eugenics", and this course shares the honors with "Genetics." However, all the colleges offer courses in Heredity or Genetics with some application to eugenics. Seven of the ten colleges include courses on "The Family" in their curricula, four offer courses in population problems, but only one (Mills College, Oakland, Calif.) gives its students opportunity to come to grips with problems of home economics. Even if these curricular deficiencies were made up, the question would still remain whether courses in eugenics and home-making will arouse in women impulses toward mating and rearing larger families. Has nature been no niggardly in endowing college women with these instincts, so powerful in men and women in general, that collegiate courses must be relied upon to stimulate the sluggish impulses of women graduates? And will these courses do the work? It is possible, but it seems to the writer highly improbable. Men and women mate and have offspring because of deep emotional drives. They limit the size of their families chiefly for reasons of health and economics. If intelligent college graduates, alert to the significance of our decreasing population and our differential birth-rate, were to receive positive public support in the form of economic and social aids, they might deliberately elect to have more children. But it seems an extremely dubious theory that academic courses, in and of themselves, can dispose men and women to increase the size of their families. — Goodsell Willystine, in *Amer. Jour. Soc.*, March, 1936.

A DOUBLE SHEEP PREGNANCY WITH A SINGLE CORPUS LUTEUM*

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RELATION OF THE FETAL MEMBRANES

Figure 3

Photograph, from the dorsal side, of the opened uterus, from which both fetuses have been removed. *A*, severed umbilical cord of fetus from left horn; *am.*, cut edges of amnion; *B*, cord of fetus from right horn; *C*, cervix; *cot.*, large cotyledons, one of which shows plainly the engorged chorionic blood vessels; *T*, a piece of tape passed through the connecting allantoic cavities of the two fetuses; *ut.*, smooth external surface of uterus; *ut. w.*, cut edge of uterine wall.

A DOUBLE sheep pregnancy with a single corpus luteum was recently discovered among 675 sheep fetuses from fresh packinghouse material. One previous case from embryological evidence points to the conclusion that monozygotic twinning may occur in sheep (Assheton[1]). Other evidence for monozygotic twinning has been sought in the frequency of the sex combinations of twins. If no monozygotic twinning occurs, the ratios of the three possible sex combinations should approximate 1 ♂ ♂ : 2 ♂ ♀ : 1 ♀ ♀, within the limits of error in random sampling and not taking into ac-

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count the slight excess of females in the gross sex-ratio at birth, provided these ratios are not materially changed by selective prenatal mortality. If monozygotic twinning occurs with any noticeable frequency, same-sexed twins would be expected in excess of opposite-sexed twins. However, instead of this being the case, Johansson[5] found an excess, though not significant, of opposite-sexed twins. Clark[3] was inclined to believe from his statistical study that in sheep most twins are of dizygotic origin. Chapman and Lush[2] sum up the present situation in their conclusion: "Hence as the matter rests now, these data give no positive indication of the existence of *any* identical twins in sheep, yet they do not rule out the possibility that such twins may occur, at least occasionally."

In the case here described the uterus measured 43 centimeters in length and 28 centimeters perpendicular to that measurement. The enlarged right ovary contained a single conspicuous corpus luteum of pregnancy, measuring $9 \times 6 \times 11$ millimeters. After discovering the presence of two fetuses in the uterus a careful search was made of both ovaries to eliminate the possibility of a second corpus luteum, but none was found.

The two fetuses (designated as *A* and *B* by their umbilical cords) were both males. The crown-rump length of *A* (left) was 42 centimeters and the fetus weighted 2,980 grams. Fetus *B* (right) measured 45 centimeters in length and weighed 3,005 grams. According to our growth curves, calculated from timed sheep fetuses of known ages, these twins would be at least 130 days old or older, and nearly approaching term. Particular attention was given to color markings on tip of nose, face, and legs, as nearly as could be ascertained at that period of development. Both fetuses were very similarly marked, appearing identical except for the slightly larger size of *B*.

A careful examination of the uterus, which was fixed in Bouin's fluid and transferred to 85% alcohol, shows the two chorions to be continuous and also a connection (presumably secondary) between the two allantois, but two separate amnions and two umbilical cords. (See Figure 3.) No septum was present, nor was there any indication that an earlier septum had been resorbed.

In this case, since there is but a single corpus luteum of pregnancy, the natural inference is that the fetuses are twins derived from a single ovum. The possibility remains, of course, that the fetuses were biovular in origin and that two ova came from a single graafian follicle. This single case was observed in examining 675 sheep fetuses for sex from fresh packinghouse material, in connection with which each ovary was carefully examined and measurements taken on the follicles and corpora lutea. In all other cases of twins two corpora lutea were found. It is concluded, therefore, that while monozygotic twinning in sheep is undoubtedly rare, the evidence for its having occurred in this case is rather convincing.

Summary

The strongest evidence in favor of a monovular origin of the two fetuses is the finding of only a single corpus luteum. Possible contributory evidence is that the fetuses were of like sex and that they were so similar in other respects. The joining of the allantoic cavities cannot be used for or against the single-egg hypothesis.

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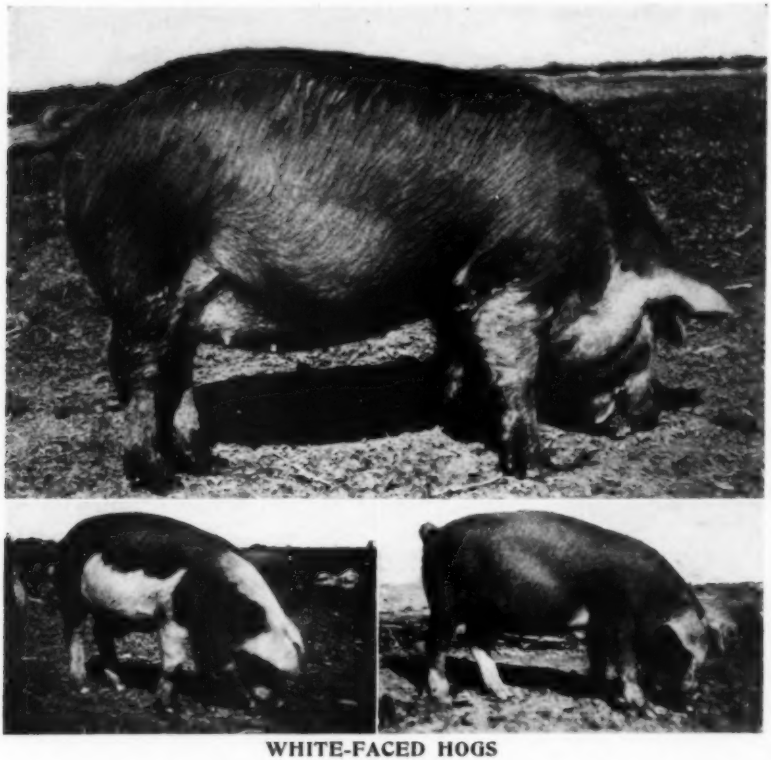
HEREFORD HOGS

ARTHUR L. ANDERSON and JON C. BONSMA*



WHITE-FACED HOGS

Figure 4

Originated by crosses of red and white breeds these pigs show the red body and white face of the Hereford. Above is a sow about 18 months old, and below a boar pig and a sow pig each about three months old.

THIS rather recently developed breed of swine was originated by Mr. R. U. Webber, La Plata, Missouri. It was his idea that this breed of hogs should parallel in color markings the Hereford breed of cattle. The foundation according to Mr. Webber is: "A cross of the white and red-blooded stock Duroc, Chesters and O. I. C.'s and a peculiar blood strain or graft. The latter being withheld until further experience can be had along that line." It is claimed by the founder that the breed was originated as early as 1902. The ideal color desired by the founder of the breed is one with a cherry red body, white face, lower part of the body white, white feet and legs and about one-half of end of tail, also, with white extending back to a point between the shoulders.

There are two record associations in this breed. The Universal Hereford Record Association, of which the founder of the breed (R. U. Webber,

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La Plata, Missouri), is secretary, was organized in 1920. More recently, 1934, the National Hereford Hog Record Association was formed. A. J. Way, of New Sharon, Iowa, is the present secretary. The pedigrees of the original association are now not recognized by the National. The new group discarded as foundation stock all but somewhat over a hundred head of well marked sows and boars, owned by six breeders and recorded in the Universal Association. It is a requirement of the younger association that all animals offered for entry must have some white in the face and must be not less than two-thirds red. The ideal markings are white head including ears, white feet, underline and switch of tail. All other parts are red, either light or dark, the latter preferred.

Although selection for a definite color pattern has been practiced, and the two associations of breeders have set an ideal, hardly two hogs are marked alike. The white markings vary in extent, but mottling, spotting, or brindling is not common. Figure 4 illustrates the difference in white extension. White over the top of the neck occurs but it does not extend over the shoulder or back, and white "line backs" present occasionally in Hereford cattle are not seen in this breed of hogs. The white underline and legs are claimed to be an advantage in slaughtering, because of the ease in scalding, dehairing and cleaning. No doubt this lack of skin pigment would result in few or none of the "seedy cut" bacon bellies present in pigmented breeds.

Occasionally, belting is noted in herds and also black markings on the skin and hair have been noted. These indicated the probable use of Hampshires in the foundation material. The red color varies in shade from light to dark. This base color may be more accurately described as reddish or rusty or light golden brown rather than cherry red which is commonly used for sandy colored hogs. The individual hair is the same shade throughout, there being no noticeable difference in pigmentation from the base to the tip. The color is a good practical one as mud and dirt are not conspicuous on such a background and pigs so colored resist sun scald and blistering.

In size, the Hereford is distinctly smaller than the other common swine breeds. In form, the pigs are somewhat compact, have very little arch to their backs and have rather short legs. The heads and ears are small in size and the bone quite refined. It is claimed that the Hereford pigs finish at a lighter weight than the usual market hogs. As rather limited numbers have been produced, the prolificacy, the rapidity and economy of gain, and other features influencing productiveness have not been studied in a comparative way.

The breeding methods used by the founder have not been completely divulged, but no doubt Chester Whites and Durocs were used for the foundation, as the characteristics shown by the Hereford suggested these two breeds as the source of the reddish brown and white. The other breeds available, the Tamworths for red and the Yorkshires for white, were apparently not used, as the form and other features do not resemble these breeds. Hampshires contributed the white belt pattern which outcrops at times and, also, may account for the casual black marks. Inbreeding has been practiced since the formation, owing to the small supply of breeding stock available.

Hereford hogs have been exhibited at some of the livestock expositions. At the 1931 Iowa State Fair eight Hereford pigs were on exhibit and at the 1936 Fair 20 head were on exhibition. Two individuals were shown at the Texas Centennial Livestock Exposition at Dallas.

The future of this breed is dependent upon its value to the hog raiser and its ability to yield a carcass which meets the approval of the American consumers of pork. Unless it can compete with the existing breeds in profit for the raiser in economy of production and market value, the breed may not be of long duration.

BRAINY PEOPLE HAVE GOOD CHARACTERS

A Review

"IF morality and intellect are finally demonstrated to be correlated throughout the whole range of individual differences, it is probably the most significant fact with which society has to deal." So spoke J. B. Miner, distinguished authority on the feeble-minded, and quoted just before the Introduction of the book now under review.* Professor Thorndike has for over twenty years voiced similar opinions. Recently in his address as President of the American Association for the Advancement of Science he has made it a major theme, and accepted the opinion that generally speaking mental qualities are correlated with virtues.

It is well that he has done so for it is not a generally recognized fact and one still sees very little about it in books on eugenics, psychology and sociology. Professor Thorndike's address must have attracted considerable attention, as my knowledge of it came from reading the Paris edition of the *New York Herald*.

Ever since 1903 when I first discovered the general truth of mental and moral correlation from statistical data in the genealogies of royal families I have followed with interest the accumulation of confirmation coming in from many different directions and dealing with many specialized traits. In 1919 I wrote a short article for the JOURNAL OF HEREDITY entitled "Good Qualities are Correlated, Hope for the Eugenist and One Objection Answered." At that time I could bring together only about a dozen researches to quote, and these dealt chiefly with rather unimportant or specialized characteristics. Investigators were discovering a relation between crime and feeble-mindedness, and that (among school children) there was a correlation between ability and certain desirable traits of character. Now we have a large book on the subject containing a bibliography of 214 titles.

"Compensation" vs "Correlation"

The supposition that bad people are very clever and the ultra virtuous not over-bright is due in part to the simple fact that we all naturally notice and remember exceptional cases. It springs from the same unscientific delusion that in former generations led most people to believe that the children of geniuses and of very rich men did not amount to much, that tall men tend to marry short women, that "the good die young," and that "ministers' sons and deacons' daughters" are apt to be not all that the punctilious might wish. The author of the volume under review seems not to consider the foregoing, but does recognize the delusion of compensation popularized in the emotionally appealing and widely read essay of Ralph Waldo Emerson as having much to do with the public's mistake. To clear up the matter we may quote (Page 3):

> The supposition that goodness and intelligence are relatively antagonistic is a natural outcome of the popular and widely held theory of compensation correctly described by Woods as "the notion that the poor, the sick, the stupid, and the generally unfortunate are the pure in heart" (cf. *Heredity in Royalty*, 1906, pp. 255-267).† Strangely enough this notion is held in spite of the fact that such an interpretation of the Beatitude referred to is belied by the conception implicit in the Parable of the Talents, since in this narrative the servants to whom more than one talent was entrusted by reason of their superior ability gave a good account of their stewardship, whereas the man who because of his lesser ability received but one talent proved untrustworthy.
>
> Within recent years, however, as the spirit of inquiry has applied itself increasingly to the problems of human nature and conduct, the question has been more and more insistently raised as to whether compen-

*CHASSELL, CLARA FRANCES. The Relation Between Morality and Intellect. A Compendium of Evidence Contributed by Psychology, Criminology, and Sociology. Pp. 556. Price $4.50. Bureau of Publication, Teachers College, Columbia University. N. Y., 1935.

†First published in *Popular Science Monthly* (now Scientific Monthly), Oct., 1903.

sation is, after all, the rule in human affairs. Woods' opinion, no doubt based in part upon his own important pioneer research regarding the correlation between mental and moral qualities (cf. "Good Qualities are Correlated," *Journal of Heredity*, 1919, pp. 84-86) is emphatically contrary to the popular conception. . . . . He says: "That the exact opposite (of compensation) happens to be the truth will not interest certain types of emotional and sentimental reformers, but persons desirous of promoting the science of heredity in its application to human problems may be interested in the evidence that accumulates from time to time, *all of which* points in one direction."

Similarly Thorndike, one of the leading investigators of the relationship between qualities, in an article on intelligence and its uses, makes this statement:

". . . in human nature good traits go together. To him that hath a superior intellect is given also on the average a superior character; the quick boy is also in the long run more accurate; the able boy is also more industrious. There is no principle of compensation whereby a weak intellect is offset by a strong will, a poor memory by good judgment, or a lack of ambition by an attractive personality. [Again in another article] . . . . a good mind means a better than average character."

These investigators are not alone in their opinion. Indeed, so practically unanimous and unequivocal have been the results of inquiries into mutual relationship of desirable qualities that the principle now appears to be established that correlation and not compensation is the rule.

One may ask what is the use of this knowledge. The author has enumerated a number of reasons why it is "exceedingly important both theoretically and practically." It will make possible "a more enlightened public opinion upon such problems as exceptional education opportunities for gifted children, the possible dangers of an intellectual aristocracy, the isolation of the feeble-minded, the sterilization of criminals, and proper emphasis in social work." It will "serve as a guide in the improvement of society through training and eugenics and in the productive utilization of man-power in every field of human endeavor, whether religion, education, industry, philanthropy or government."

The book is divided into two parts. The first concerns delinquency and mental inferiority, the second deals with normal persons and their mental and moral correlations. A great deal has been done in the way of proving the mental deficiency of juvenile delinquents, sex offenders, alcoholics and adult criminals. In Tables I to V the author lists no less than 157 different researches. Most of these show significant positive relationships ranging from .10 to .91 (the reader should remember that 1.00 means perfect correlation). There are, however, 23 out of the 157 where the coefficients are extremely low or negative. Many of these are highly specialized and so it is not surprising, as for instance one on page 99 where there is little correlation between degree of alcoholism and mental inferiority; and again in Germany (p. 75) sex offense shows slight correlation with mental retardation. It is especially interesting as showing how unrelated crime is to illiteracy that one group in the United States of 22,664 adult criminals yields a positive coefficient of only .12, while another group of 50,677 in the United States and Canada shows a minus coefficient of .06. The same is true in Germany. The inference is that teaching people to read makes no difference one way or the other in their propensity towards crime.

In regard to abstract and concrete intelligence the adult criminal as well as the juvenile offender appear deficient, but for mechanical intelligence there are five tests reported which indicate that juvenile delinquents are fully up to the average in this respect. It suggests the reason why criminals are often experts in lock-picking, burglary, automobile work, safe-breaking, etc. That is confirmed on page 177, where it is shown that there is little or no relationship between conduct of school children and mechanical intelligence.

The amount of variation in the diverse researches is curiously striking, but the general tendency toward positive correlations well beyond the probable errors is unmistakable. As the author puts it: "In conclusion there-

fore it may be stated that the evidence as to the relation between delinquency (crime) and mental inferiority presented in Part IA of the research varies greatly, but indicates that a direct marked relation exists between morality and intellect among feeble-minded groups, and that a direct and low relation exists among delinquent groups (and deficient intelligence) in this country and abroad."

Correlations of Positive Qualities

The second section of this book is even more replete with tabulated researches. It extends from Page 137 to 418 and deals with mental and moral correlations among groups of presumably normal persons. It seeks to find ratios for such specific virtues as trustworthiness, cooperation, sincerity, loyalty, sympathy, kindliness, industry, etc., and (also general excellence of character) with such mental excellences as quickness of apprehension, accuracy, retentiveness of memory, profoundness of apprehension, originality of ideas, leadership, social intelligence, etc. This whole batch of material is labelled at the top of each page "Non-delinquent." That is because, for so many years, nearly all investigations were carried on among delinquent youths or criminals. Few seemed to realize the general application to normal adult human beings. Thus you and I have come to be known in psychological laboratories as "non-delinquents." Except for my own research (608 royalties) showing a generalized correlation of many virtues with many intellectual traits, 1903 and 1906, and that of Pearson on the single trait conscientiousness and ability among school children, 1906, apparently none of the investigations antedate the European War except Goring, 1913, on extreme forms of alcoholism and mental defectiveness. Kelley appears in 1914, Webb 1915, Folsom 1917, and Miner 1917. After this more voices were heard and now a multitude have joined in the chorus.

In final conclusion (p. 492) the author writes:

> . . . The fact that the individual results of the research show comparatively few instances of negative correlation, and the summarized results with but few exceptions—regardless of the type of evidence, the type of group, the country, and type of coefficient—show a positive correlation, is a sufficiently impressive outcome. Moreover, it is evident that, in spite of the conservative nature of the conclusions formulated, an affirmative answer can yet be given to the question raised at the beginning of this research. The principle of the mutual relationship of desirable qualities still remains unchallenged: as far as the relation between morality and intellect is concerned correlation and not compensation is the rule.

Its Bearing on Historiometry

These many results confirming each other as they do have an important appeal for students of philosophy of history and for believers in the possibility at no distant date of a true science of history will be evolved. They bring added proof supporting my long-held contention that the common facts of history are sufficiently accurate to be utilized in constructing an objective science. For how, otherwise, would it be possible from ordinary encyclopedias, biographies and histories to have obtained such definite correlations as I have in my studies of royalty both for heredity and for mental and moral relationship? If the historians, biographers, *et al* had not made a fair approach at telling the truth there would have been little or no correlation discovered. Furthermore, I had already graded the individuals (in consultation with several experts) for the study of mental and moral heredity before finding the mental and moral correlation. Further proofs are to be found in my "Historiometry as an Exact Science"—*Science*, April 14, 1911—and my "Influence of Monarchs," N. Y., 1913. The reason for mentioning historiometry here is that history *has brought* and *can bring* much to the science of human genetics.

In bringing to a close the review of this excellent and scrupulously accurate book it is important to think of the bearing of it all on eugenics. There are many reasons *a priori* for believing

that the domestic, unselfish, and virtuous rear more adult offspring than the unfaithful, selfish, or depraved. It is well known that criminals are apt to die young and do not leave many children. As long ago as 1903 in the same research already referred to, I found all the four upper grades of royalty (already graded for general virtues) to show distinctly more adult offspring than the four lower. To this may be added the fact that within all small groups yet studied the intellectually superior, successful or eminent have more offspring than the inferior. There has been considerable written lately on this theme by myself followed by A. E. Wiggam, John C. Phillips and others.*

Because those in the superior moral grades have more children and morality in its widest sense is bound up with so many desirable intellectual traits, we here see how mental and moral evolution has taken place. Indeed, these forces may well have been the chief cause of civilization. It all gives an encouraging outlook for the future. It is a calm outlook for the philosophically inclined and one that is at present but little appreciated. F. A. Woods.

✦

THE BIOLOGICAL EFFECTS OF WAR

AS is emphasized in the *Vorwort* of the present volume, military power depends fundamentally on numbers.† Hence it is important for a nation to see to it that its numbers do not decrease. The first part of Burgdőrfer's brochure is devoted to setting forth the present condition of Germany as regards population growth. "Maintenance of the strength of a people," the author states, "must be the aim of aims, not primarily on account of military power, but on account of the people and their historical mission." Germany is strenuously endeavoring to increase her manpower, but the author hastens to add that "race culture and war are irreconcilable opposites."

Unfortunately, the argument continues, Germany is in the midst of enemies, shorn of territory, and subject to many injustices. However greatly war is to be deplored, Germany must be strong and capable of regaining and maintaining her rights and her honor. Her population should increase more rapidly. As it is, the natural increase of her people threatens to cease in the near future. Burgdőrfer's essay sets forth and illustrates with statistical tables and graphs the recent trend in changes of age composition of the people and the changing proportion of men eligible to military service. His book is a cry of alarm and a plea for the nation to rouse itself and take measures to counteract the menace of decreasing numbers.

The second part of the volume on "War and Race" contains a valuable summary of the demographic effects of the World War. The first section deals with the effects of the system of recruiting on marriages and births. Before the war the general influence of this system was probably dysgenic, for reasons which the author supports with considerable statistical evidence.

The second section on losses in the World War gives for several countries an impressive array of data on deaths in battle as related to age, occupation, marital condition, and military status, deaths in the civil population, the decline of the birth rate during the war, and the after-effects of the war on the quality and trend of the population. According to Burgdőrfer, the biological effects of war are bad. In support of this conclusion he quotes in a prefatory

*See *Journal of Heredity* July, 1927, June and September, 1928; *Metron*, 1928; Congress Internazionale per gli Studi sulla popolazione, Roma, 1932.

†Burgdőrfer, Friedrich: Volks und Wehrkraft, Krieg und Rasse. Berlin, Metzner, 1936, pp. 138.

motto the declaration of Adolf Hitler to the effect that every war devours the best of the population. But he does not attempt to emulate Der Führer's dexterity in waving an olive branch with one hand and brandishing a sword in the other. On account of the convincing statistical evidence which the author usually adduces in support of his generalizations, Dr. Burgdörfer's discussion of the biological effects of war is one of the most valuable that has appeared.

University of California S. J. Holmes

Manners

To the Editor:

Since Mr. Cook has given an exhibition of bad manners in his review of Mr. Bernard Jaffe's "Outposts in Science," let me add a little exhibition of my own, and this on the doubtful theory that the best cure for bad manners is more bad manners.

I do not know Mr. Jaffe, but I did read his book critically. I do not know Mr. Cook, but I do know that he wrote just the kind of review that ought to be deplored, whether his points are right or wrong.

For years scientists have held up most attempts at the popularization of science to scorn. Along comes a man who patiently gathers facts from about 50 scientists, and then takes the trouble to submit what he has written to his informants to make sure that he has done them no injustice or written anything that can possibly mislead the public. Yet Mr. Cook sits down and rather grudgingly concedes some merit to the resultant book and proceeds to tear to pieces one section which deals not with Mr. Jaffe's views on the genetics, but with Dr. Maud Slye's. Mr. Cook ought to read the reviews of popular scientific books which are published in *Nature*. He will find them models of their kind, written by men who know their subjects and who realize that teachers like Mr. Jaffe should be commended for their conscientious effort to state facts clearly and accurately, though they may not achieve 100 per cent perfection.

I hope for his own sake that Mr. Cook had his tongue in his cheek when he suggested that Mr. Jaffe had done much harm by spreading abroad Miss Slye's views. This is the sort of silly exaggeration to which scientific reviewers of books on popular science are given. I begin to suspect that some mysterious gene prevents them from writing with judicial propriety. In fact, they are much like Japanese waltzing mice in this respect.

Incidentally Mr. Cook himself speaks with a finality about Felix Bernstein's work that displays no great knowledge of what the mathematician can do even with the inadequate statistical material as yet available in genetics. Indeed when it comes to the mathematical aspects of their subject matter the geneticists need considerable enlightenment. Anybody who knows what Bernstein did with blood groupings ought to realize that so brilliant a mathematician has much to contribute to our genetic knowledge of cancer.

Faithfully yours,
Waldemar Kaempffert

Jan. 18, 1937

Debutantes

To the Editor:

There is a universal demand that scientific facts be presented to the public. When these facts make their debuts folks who are scientifically inclined want to see them in Mother Hubbards without makeup, and want to observe how they behave in a household with other scientific facts. But the great majority of people prefer them in ballroom dresses, with plucked brows, false lashes, and crimson lip-nail combinations. Some even demand a cocktail breath and don't care a hoot whether the jabberings of these epistemological debutantes make sense or not, so long as they provide exciting reading—"believe it or not"!

If the amanuensis arranging the debut is a scientist, the fact-debutante is liable to wear gingham and go unnoticed. If our "debutante's" "Relations Council" writes for a living, however, he is apt to employ dazzling tinsel and Hollywood glorification to assure financial returns for his trouble, but subjects himself to criticism from the scientific minority. The scientist is sometimes prejudiced, while the professional writer is frequently led astray by the source of his information and does not know where to go to get authoritative confirmation or denial. Sometimes the professional writer has what some scientists are tempted to call, on the basis of painful experience, "a news reporter's disregard for accuracy."

Similar conflicts are found elsewhere. It is sometimes difficult to distinguish between serious sketches and cartoons. There is a constant skirmish going on between truthful representation of articles offered for sale and some very successful advertising campaigns based on misrepresentation and distortion of the facts (vitamins, throat-cure cigarettes, etc., etc.). National information is opposed to political propaganda, history to drama, and others *ad infinitum*. In genetics *vs.* eugenics the apparent conflict is due to whether the emphasis is placed upon the "fact" or upon the "hope"—plus the *methods* of applying our hopes—which can never be strictly a problem in applied genetics.

Such problems will continue to bother us, and are virtually insoluble because of the public preference for gay costumes. It is the duty of scientists to promote the dissemination of unadorned truth and to correct erroneous impressions whenever they get loose. This latter duty is particularly difficult and thankless and its performance is frequently followed by personal attacks and literary reprisals. Only too often a pitched battle ensues, with the participants alternately bobbing up long enough to yell, "You never touched me!" and one or both throwing mud until both sides finally get tired and quit.

Mr. Cook's review of Mr. Jaffe's book is a timely example. Mr. Cook apparently realizes the need for popular interpretative enlightenment regarding scientific work and the necessity of curbing erroneous interpretations no matter how they get into circulation. Apparently he felt that Jaffe's chapter on Cancer Research was a bad interpretation of that field, and that he had employed as its heroine one whose work, while accepted in some circles, has caused considerable misgivings among fellow carcino-geneticists. In September Mr. Cook "stuck his neck out" by publishing his critical review and the battle was on.

In December Mr. Jaffe admitted that Mr. Cook made three points: (1) too much sugar coating, (2) glorified a single personality, (3) peddled some conclusions unwarranted or altogether inaccurate. He disposes of the first point by listing testimonials from people who said only nice things about his book, *one* of these being a distinguished geneticist. He eliminates the second by saying that he is willing to consider the work of other carcino-geneticists in a future revision of his tome. In answer to the third point he says, "Still I accepted the conclusions of the courageous Maud Slye because they were bolstered up by Felix Bernstein, one of the world's most eminent mathematical statisticians as well as by the judgment of others."

If Mr. Jaffe had stopped right there, all well and good. But then Mr. Jaffe said some naughty things about personalities. He said that Mr. Cook's review was "written in bad taste" and that Mr. Cook had sunk "to the low level of unkindness in attacking not only Maud Slye's knowledge of the laws of genetics, but even her poetic expressions. What chivalry toward a woman who is giving a life to scientific research."

Now it's Mr. Cook's turn. He is sorry if his review exceeds the bounds of good taste. And then he has to go and spoil it by flicking the mud pellet that he "is not certain, however, that he is the first to sin in this respect" of bad taste. He then upholds his previous points and adds the important fact that "the errors discussed in the review are not merely of theoretical implication, but are of a nature to exert considerable influence on medical and lay attitudes with regard to the cause and control of cancer." He suggests that the error is not in Bernstein's statistics but in the data upon which he worked. Mr. Cook tosses back one about trying to red herring the focus away from the facts under discussion into a discussion of "chivalry toward a woman." He tosses back also the one that although the heroine's "verses are excellent" he does not think that they "have much to do with the strictly scientific aspects of 1935 cancer genetics."

Next, Mr. Jaffe pops up and says that Dr. Conklin will have to decide whether he read the whole book carefully before he sent his bouquet. He gloats that Mr. Cook did not reply to the second point about putting other people besides Miss Slye on pedestals and agrees that "conclusions drawn from most genetic experiments must be examined very carefully." He says that "to say that I have raised 'a sex distinction in scientific research' is to come perilously near to being ludicrous." He couldn't stop at that but had to toss this one: "Rather has nature created an *emotional* distinction which stamps the scientist who cannot fairly appraise the work of those who differ with him." And with that smeared all over Mr. Cook's face and dripping down his shirt front, Mr. Jaffe thanks him for all the kind things he had said in his review. Then while Mr. Cook is rubbing the mud out of his bewildered eyes Mr. Jaffe pastes him with the hat full that THE JOURNAL OF HEREDITY "owes Maud Slye an apology."

Mr. Cook comes back gamely that he doesn't care to propose contemporary carcino-genetic names for pedestals and that the genetic statements which he cited from Mr. Jaffe's book were still wrong, which was what we were discussing before the matter got tangled up in personalities.

We thought that it was to end there, but at the Atlantic City meetings it appears that the heroine of the story changed her interpretation for which both Bernstein and Jaffe had done battle (See *Science* 85:157, Feb. 5, 1937). It now appears that Miss Slye's one recessive gene for cancer has given rise to a numerous progeny of a dozen or twenty independent recessive genes, whose debut at Atlantic City was a high spot in the cancer symposium. The public abandonment by Miss Slye of a position which has caused much conflict in the field of carcino-genetic research represents a wholly unexpected *finale* to the Jaffe-Cook exchange. Now, who owes whom an apology—and *why?*

But still the scientific facts look so nice in their party dresses whether they make sense or not. And still we must know how they are going to behave in a household with other scientific facts. So after this inky skirmish we may as well tidy up the battlefield for the next round of this perennial war in which the words will no doubt continue to go 'round and 'round, and come out *where?*

CLYDE E. KEELER
Howe Laboratory, Harvard Medical School.

A GLOSSARY OF GENETIC TERMS

THE GLOSSARY on the following pages culminates an attempt which has been "in process" for nearly twenty years to make understandable to the not over-technical reader the peculiar lingo of genetics. Its first beginnings were published in 1918 (Volume 9, Page 91, of the JOURNAL). About five years ago the experiment was tried of publishing on the back cover of each issue of the JOURNAL a "Glossary of the Technical Terms" used in that issue. The plan met with a varied response—covering the entire spectrum of approbation from enthusiastic endorsement to violent condemnation. About three years ago, in response to a good many requests for a more complete Glossary all in one piece, a revision of the back-cover Glossary was undertaken. After going over all objections that had been raised against the terms used (many having been considerably revised while in use) this somewhat expanded Glossary was issued as an advance proof, copies of which were mailed with the bills sent out in 1936.

These proofs have elicited a great many responses,—suggestions, changes, objections, "cussions" and discussions *pro* and *con*. It will probably be of interest, and may be worthwhile as a measure of protection to the Editor, to show the range of response by brief quotations: "The definitions are 'too learning-bound.'" . . . "I can hardly see what use your Glossary will serve in its present condition, and I believe it will be, if not improved, a detrimental influence on genetics as a science. There seems to be no excuse for popularization if it entails a complete overthrow of scholarliness." . . . "It is a valuable thing you are doing in compiling a Glossary of genetic terms." . . . "'Sex Chromosome' is a direct perversion of language, and unless we want to continue a 'witch-doctor's' sort of genetics, we will not use it since it is a contradiction of the facts." "I believe the Glossary is a good move and would suggest that it needs considerable revision." [The Editor: Amen.] . . . In regard to your excellent Glossary of Genetic Terms, there are a few minor suggestions . . ." . . . "We all think that it needs very careful and thorough revision over and beyond the few suggestions that we have made . . . I know of course it is very difficult to make set definitions; all the more reason for doing it with extreme care." . . . "I wish to congratulate you on the Glossary of Genetic Terms."

During the intervening months the Editor has gone over all of the suggestions received and has prayerfully endeavored to squeeze the last bit of value out of them. They have all been most helpful and have been tremendously appreciated. That the result falls so far short of perfection is certainly not the fault of those who have so generously given time and thought. The percentage of outspokenly critical comments is higher in the above compendium than in all the letters, so that our genetic public as a whole seems to favor the idea.

When the need for more work is regretfully admitted, why publish the Glossary at this time? There are at least two rather compelling reasons. A glossary has been promised in booklet form, and it is not fair to withhold performance indefinitely. Since the Glossary is necessarily an "as opportunity offers" job, there is little likelihood that it will advance far toward perfection in a few months more. Its publication in the JOURNAL in its present state, admittedly imperfect, is more an invitation to further suggestions and corrections than a claim that the last word has been said. After final revision it is proposed to issue a new edition of the Glossary in booklet form as a verbal life raft for those who may find the jargon of Genetics as exemplified in the pages of the JOURNAL and elsewhere, an obstacle to exploring that mysterious and complicated Land of the Gene.

The difficulties of producing a reasonably complete set of definitions, neither "unscholarly" nor "learning bound," is obvious. There are in practice many further complexities. Thus when one attempts to convey an idea of the "Gametophyte-Sporophyte" cycle the fun immediately begins. To cover all the variations from algae to angiosperms requires most of a chapter in a text book on cytology. It is hardly fair to label such a term "non-genetic" and let it go at that, because it is a term frequently seen in genetic discussion. Obviously the result is mostly "all wrong" but looking over the best dictionaries' and cytologies' definitions and discussions, the Editor only challenges "do better" 'and has to let it go at that. "Aleurone," as *used in genetic discussions*, has similar complications. These examples are only cited to recall the complexities and difficulties that have been encountered in trying to get on with this endeavor. Other difficulties have beset the compiler in deciding what to include. Many terms were "nominated" which could not be added because of the limitations of time and space. Other borderline terms were left out because their genetic use should be clear from the ordinary sense of the word. Other new terms were withheld because they are not current in genetic literature. Some (like sex-chromosome, above) were included over violent objections, because the compiler cannot attempt to act as an arbiter of genetic thinking.

With many misgivings, and with a painful realization of the simultaneous need both for more learning and for less of the trappings of learning, the Glossary is presented for what it is worth and with an earnest plea for suggestions to make a revision of it both more accurate and more easily comprehended.—EDITOR.

A GLOSSARY OF GENETIC TERMS

A

ACQUIRED CHARACTER—A modification of structure impressed on an organism by environmental influences during development.

AGGLUTINATION—A reaction (probably chemical) in vivo or in vitro, between agglutinins (antibodies) and agglutinogens (antigens), which is characterized by a clumping together of the cells bearing the agglutinogen (as occurs when incompatible bloods are mixed).

ALEURONE—The outer cells of the endosperm of a seed (graminae) which appear as a layer or layers of thick walled cells.

ALLELOMORPH (ALLEL, or ALLELE)—The alternative forms of a gene, having the same locus in homologous chromosomes. Thus in many organisms there is a gene which produces albinism. This is usually recessive to the gene for normal pigmentation, which is a dominant allelomorph of albinism.

ALLOPOLYPLOID—A polyploid having chromosome sets from different sources (such as different species). (2) A polyploid whose chromosomes do not usually form multiple groups at meiosis but pair as far as their homologies allow them. (*cf. Autopolyploid.*)

ALLOSOME—A special kind of chromosome distinguished from the ordinary chromosomes or autosomes by certain peculiarities of behavior and sometimes by a difference in size and shape. (See sex-chromosomes.)

ALTERNATIVE INHERITANCE—See Allelomorph.

AMITOSIS—Cell division in which the nuclear division does not involve the formation of chromosomes or a spindle.

AMPHIMIXIS—Cross-fertilization.

AMPHIDIPLOID—A hybrid having diploid sets of the chromosomes of both of the parent species (or genera). Such forms occasionally arise in normally sterile hybrids (probably by the failure of complete nucelar division during mitosis, and are self fertile.

ANAPHASE—The later stages of mitosis during which the daughter chromosomes diverge from the equatorial plate.

ANEUPLOID—An organism having a chromosome complement in excess (or deficiency), of an exact euploid number; e. g., a trisomic ($2n + 1$) or a monosomic ($2n - 1$).

APOGAMY—The production of a sporophyte from the gametophyte by a vegetative process, without the formation or union of gametes.

APOSPORY—The development of a gametophyte from a cell (or cells) other than a spore (in plants normally developing gametophytes from spores).

ASEXUAL—Not involving germ cells or fusion of nuclei; said of reproduction, or propagation or of an individual restricted to such a mode of reproduction.

ATAVISM—Reappearance of a character after a lapse of one or more generations, as when a recessive character reappears after being transmitted through several generations of heterozygous individuals.

AUTOPOLYPLOID—A polyploid having multiple chromosome sets derived from the same phylogenetic source.

AUTOSOME—Any chromosome except an allosome.

B

BACKCROSS—The mating an F_1 hybrid to one of the parental races crossed to produce the F_1 hybrid.

BIMODAL—A frequency curve characterized by two "peaks."

BIOMETRY—Application of statistical methods to the study of biological problems.

BIVALENT—Referring to the homologous chromosomes united or associated in pairs.

BLASTOMERE—One of the cluster of cells formed as a result of the first few divisions of the animal egg.

BLENDING INHERITANCE—Inheritance in which the F_1 is intermediate between the parent types with respect to a given character difference and in which clearly defined segregation is lacking in the F_2 generation. Genetic and biometrical methods have shown this is due to multiple factors independently inherited or to lack of dominance.

BRACHYCEPHALIC—Short-headed.

BRACHYDACTYLY—Occurrence of short fingers or toes due to shortness of the finger bones (brachyphalangy) or to the absence of one of the phalanges.

BUD MUTATION—A mutation affecting a bud, so that it gives rise to a branch (flower, etc.) differing in one or more characteristics from the rest of the plant.

C

CELL—"* * * there is one universal principle of development for the elementary part of organisms, however different, * * * and this principle is the formation of cells" (Schwann, 1839). In these usually miscroscopic "building blocks of living organisms" we find a nucleus and other cell organs surrounded by cytoplasm, all enclosed within a cell wall.

CENTROSOME—A minute body generally present in animal cells and in the cells of some lower plants, but rarely visible in flowering plants. It is the center of the *astral rays* (which appear during mitosis, and form the *aster*) which play a conspicuous part in cell division.

CHARACTER (a contraction of characteristic)—A term used, often rather vaguely, to designate any form, function, or feature of an organism. The mendelian characters of genetics represent the end products of development in which a definite gene, or genes, have a decisive effect. "The constant and unchanging thing, therefore, is the factor (gene) itself rather than the character, and the unity which Mendel observed lies rather in this underlying factor than in the visible, and perhaps variable, character which it produces."—Sinnott and Dunn.

CHIASMA—"In the diplotene stage [of meiosis] the chromatids are associated in pairs in such a way that in one part of their length two chromatids are associated but in another part each is associated with a different chromatid. The point of exchange is termed a chiasma." (Sansome and Phipp, 1932.)

CHIMERA—An organism composed of tissues of two genetically distinct types as a result of mutation, segregation, irregularity of mitosis, or artificial fusion (grafting), etc.

CHROMATID—Chromosomes frequently bear the foreshadowing of one or more future longitudinal divisions so that they appear to be made up of parallel threads. These threads are the chromatids.

CHROMATIN—That part of the nuclear substance which forms the most conspicuous part of the nuclear network and the chromosomes, and stains deeply with the "nuclear" or basic dyes.

CHROMOCENTER—Inert chromatin to which the chromosome elements are attached in the salivary glands of Diptera.

CHROMOMERE—One of the linearly arranged chromatin granules comprising the chromosome. (Identified by Belling and others with the gene and by more recent workers considered an artifact produced by fixation of spirally coiled chromatids.)

CHROMONEMA—A fine thread of chromatin material from which arises the spireme thread.

CHROMOSOME MAP—A diagram showing the relative position of genes in linkage groups, determined by observation of cross-over frequencies, or by other means.

CHROMOSOMES—Tiny, dark-staining bodies visible under the microscope in the nucleus of the cell at the time of cell-division. The number of chromosomes in any species is usually constant. The chromosomes carry the genes, linearly arranged.

CLONE—The offspring produced by asexual reproduction of a single animal or plant, as in (1) Protozoa, (2) vegetative propagation as in Hydra or many plants, or (3) by secondary splitting of a single fertilized egg, such as the quadruplets in the armadillo or uniovular twins in Man.

COLLATERAL INHERITANCE—A term used to describe the appearance of characters in collateral members of a family, as when an uncle and a niece show the same character, inherited by the related individuals from a *common* ancestor. Collateral inheritance is characteristic of recessive characters which appear irregularly, in contrast to dominant characters which do not skip a generation in inheritance.

COMPLEMENTARY GENES—Genes which are similar in effect when inherited separately, but which together produce a distinct character. Thus the *C* and *P* genes in sweet peas each produce white flowers, but the combination (*CcPp*, *CCPp*, *CcPP*, *CCPP*) produces purple flowers.

CONGENITAL—Present at birth.

CONJUGATION—Side-by-side association of homologous chromosomes as in the reduction division.

CORRELATION—A relation between two quantities such that an increase or decrease of one is, in general, associated with an increase or decrease of the other. The degree of linear correlation is measured by the correlation coefficient (r), which may range in value from -1 to $+1$; a negative correlation coefficient indicating reciprocal correlation.

COUPLING—The association of characters in inheritance, due to linkage.

CROSSING OVER—The exchange of linkage relations between two characters due to an interchange of segments between the chromatids of two homologous chromosomes in the germ cells early in meiosis. This results in a change in the linkage relations of the characters as they appeared in the parents. See *Chiasma*.

CYTOLOGY—The study of the structure and function of the living cell.

CYTOPLASM—The protoplasm of a cell in which the cell organs (nucleus, plastids, etc., are embedded.

CYTOPLASMIC—Pertaining to the protoplasm outside of the nucleus; said of inheritance dependent on the cytoplasm or on objects contained in it.

D

DEFICIENCY—Absence or "deletion" or inactivation of a segment of a chromosome.

DELETION—Absence of a segment of a chromosome involving one or more genes.

DETERMINANT—A hypothetic element in the chromosome postulated by Weismann to control development. Precursor of the gene-concept.

DETERMINER—An element which controls the development of a Mendelian unit character. Historically the determiner lies between Weismann's *Determinant* and the modern concept of the gene. It is gradually falling into disuse, "gene" and "factor" taking its place.

DIAKINESIS—A stage of meiosis in which the homologous chromosomes are associated in pairs, just before reduction, when the pairs separate to complete the heterotypic mitosis in which the chromosome number is reduced.

DIFFERENTIATION—The process whereby cells and tissues become specialized for specific functions during the process of growth and development.

DIGAMETIC—Having gametes of two classes, in particular a male-producing and a female-producing class.

DIHETEROZYGOTE—Dihybrid.

DIHYBRID—An individual which is heterozygous with respect to two pairs of allelomorphs.

DIPLOID—Having two sets of chromosomes. Body-tissues of higher plants and animals are ordinarily diploid in chromosome constitution in contrast with the haploid gametes. See *Somatic*.

DIPLOTENE—A stage in meiosis, preceding diakinesis.

DISOME—A chromosome set having paired members, as in normal somatic tissue.

DISPERMIC—Fertilized by two sperm cells.

DIZYGOTIC—Originating from two fertilized eggs. (In contrast with monozygotic.) Dizygotic twins are genetically no more similar than ordinary brothers and sisters.

DOMINANT—A character possessed by one of the parents of a hybrid, which appears in the hybrid to the exclusion of the contrasted character from the other parent (the recessive). Thus in a cross of green- and yellow-seeded peas the first generation has yellow seeds. Yellow is dominant and green is recessive, being transmitted but not appearing in the presence of the factor for yellow.

DUPLEX—Diploid.

DUPLICATE GENES—Two or more pairs of genes having similar effects on one character.

DYSGENIC—Tending to impair the racial qualities of future generations; the opposite of eugenic; as for example subsidizing a high birthrate among the genetically defective.

E

ECTOGENESIS—Development of an embryo by artificial culture in vitro. (Production of "test-tube babies.")

EGG—A germ cell produced by a functionally female organism. In animals, an ovum.

ENDOSPERM—Triploid nutritive tissue found in the embryo sac of the seed plants. It arises by "double fertilization" of a second male nucleus (introduced at fertilization) with two of the eight nuceli of the embryo sac.

EPIGENESIS—The concept of generation now accepted by biologists, which holds that the germ or embryo develops afresh in each generation through the interaction of genes and other protoplasmic components with the environment, in contrast with the theory once held that development was merely an unfolding of organs already microscopically present in the egg.

EPISTASIS—The suppression of the action of a gene or pair of genes by genes not allelomorphic to the gene suppressed. Thus, the gene for wild pattern (agouti) in the rabbit is masked in the albino. An effect similar to dominance but involving the interaction of non-allelomorphic pairs of genes. Albinism in this case is said to be epistatic over the wild pattern which is hypostatic to albinism.

EQUATORIAL PLATE—The figure formed by the metaphase chromosomes lying at the equator of the spindle during mitosis.

EUGENICS—The application of knowledge of heredity to the improvement of the human race. "The study of agencies under social control that may improve or impair the racial qualities of future generations, either physically or mentally."

EUPLOID—An exact multiple of the monoploid or haploid chromosome number. Terms in a euploid series are *diploid, triploid,* etc.

EUTHENIC—Tending to produce better conditions for people to live in (but not necessarily tending to produce people who can hand on improvement by heredity).

EXTENSION FACTOR—A factor (gene) which extends the action of a primary factor. Thus, in mammalian genetics, black or brown pigments restricted chiefly to the eye, become "extended" throughout the coat in black or brown varieties.

F

F_1—(Pronounced eff-one). The first filial generation. The first generation offspring of a given mating.

F_2—The second filial generation. Produced by crossing *inter se* or by self-fertilizing the F_1. The inbred grandchildren of a given mating. The term is loosely used to indicate any grandchildren of a given mating, but in controlled genetic experimentation inbreeding of the F_1 (or equivalent) is implied.

FACTOR—Same as *Gene*, though by some geneticists considered of less definite connotation.

FERTILIZATION—The name given to the events occurring after pollination or mating, which culminate in the fusion of a male gamete with an egg and initiate the development of an embryo.

FISSION—Division of a one-celled organism into two equal parts in asexual reproduction.

FOLLICULAR HORMONE—A hormone formed by the ovarian follicles of the ovary. One of the female sex hormones.

G

GAMETE—A reproductive cell of either sex; e. g. sperm or an egg (ovum).

GAMETOGENESIS—Formation of gametes.

GAMETOPHYTE—That phase of many kinds of plants which bears the sex cells. (2) A plant which bears sex cells. In plants the sexual and asexual generations alternate. In higher plants the gametophyte generation is an inconspicuous part of the plant. (Cf. *sporophyte*).

GENE—(1) The unit of inheritance, which is transmitted in the germ cells, and which by interaction with the genic and cytoplasmic complex and the environment controls the development of a character. The alternative units (allelomorphs) occupying the same locus are held to be phases of the same gene. The genes are held to be arranged linearly in the chromosomes. (2) "The physical basis of heredity."

GENETICS—"Genetics is the science which seeks to account for the resemblances and differences which are exhibited by organisms related by descent" (Babcock and Clausen).

GENOM—A chromosome set, as it is inherited as a unit from one parent.

GENOTYPE—The entire genetic constitution expressed and latent, of an organism, in contrast to *phenotype*.

GERM CELL—A cell capable of reproduction, or of sharing in reproduction, as contrasted with the somatic or body cells which are not specialized for sexual reproduction. More strictly, a reproductive cell that has undergone, or will undergo, or whose cell descendants will undergo, oögenesis or spermatogenesis before participating in reproduction.

GERMPLASM—The material basis of heredity, taken collectively. The sum of the gene-constitution of an organism.

GONAD—A reproductive gland, or group of glands; an ovary, testis or hermaphrodite gland.

GYNANDROMORPH—An individual of which one part of the body is female in constitution, and another part is male.

H

HAPLOID—Single; referring to the reduced number of chromosomes, as in the mature germ cells of bisexual organisms. Cf. *diploid*.

HEREDITY—The occurrence, in organisms, of qualities, expressed or latent derived from their ancestors.

HETERO-FERTILIZATION—The fertilization of the endosperm and embryo nuclei by gametes of different genetic constitution. (See *Endosperm*.)

HETEROGAMETIC—Producing unlike gametes (with respect to the sex chromosome). In the "*X-Y*" group of organisms the male is the heterogametic sex, producing *X*-bearing sperm and *Y*-bearing sperm in equal numbers. In the "*W-Z*" group (including moths and birds), the female is heterogametic, producing *W*-bearing ova and *Z*-bearing ova; the sperm-cells all carry a *Z* chromosome.

HETEROPLASTIC GRAFT — Transplantation of tissue from an individual of one species to an individual of a different species or even a different genus.

HETEROPLOID—An organism characterized by a chromosome number that is not a multiple of the basic haploid (monoploid) number.

HETEROSIS—Hybrid vigor.

HETEROSYNAPSIS — Synapsis between unlike chromosomes.

HETEROTYPIC DIVISION—One of the two meiotic divisions, in which the homologous chromosomes are separated to form daughter cells with the haploid chromosome number.

HETEROZYGOTE—An organism heterozygous (hybrid) with respect to any given pair of allelomorphs; that is, containing two different forms of the same gene.

HETEROZYGOUS—Containing both genes of an allelomorphic pair, or two different genes of an allelomorphic series.

HEXAPLOID—An organism characterized by having six times the basic haploid (monoploid) number of chromosomes.

HOMEOPLASTIC GRAFT—A graft of the tissue of an animal to another animal of the same species.

HOMEOSIS—The assumption by one of a series of parts of the characters proper to another member of the series.

HOMEOSYNAPSIS—Synapsis between like chromosomes.

HOMOLOGOUS—Chromosomes occur in somatic cells in pairs; two members of a pair are spoken of as homologous chromosomes.

HOMOTYPIC DIVISION — The non-reductional meiotic division.

HOMOZYGOTE—An organism whose parents contributed to it similar genes for some inherited character, and whose germ cells are therefore all alike with respect to the genes for that character.

HOMOZYGOUS—(1) [An organism] formed by germ cells alike with respect to a given gene. (2) An organism is said to be homozygous for a given character when all its germ cells transmit identical genes for that character. This is the most frequently used meaning of the term.

HORMONE—The active principle secreted by a ductless gland, or any substance produced in one part of the body that has an effect on other parts. "An organic catalyst."

HYBRID—The offspring of two parents unlike one another in one or more heritable characters. (2) A heterozygote.

HYBRIDIZATION—The process of crossing plants or animals of unlike hereditary constitution thereby producing F_1 offspring heterozygous for the genes in which the parents differ.

HYBRID VIGOR—When two unrelated stocks are crossed the hybrids frequently exceed either parent stock in size and vigor, this phenomenon is called hybrid vigor or heterosis.

HYPOMORPHIC (Mutation)—A gene mutation producing an effect similar to, but not so great as, that produced by a gene loss (deletion).

HYPOSTASIS—The condition of non-allelomorphic recessiveness. (See *Epistasis*). Hypostatic (adj.).

I

IDENTICAL TWINS—Two individuals developed from the same fertilized egg. They are extremely alike and are generally (but not always) found in the same chorion before birth. Monozygotic twins.

INBREED—To mate related plants or animals. The genetic effect of inbreeding is to increase homozygosis, resulting ultimately in the production of a pure line.

INBREEDING COEFFICIENT—A measurement of the intensity of inbreeding. Wright's coefficient (the one most frequently used) measures the extent to which inbreeding has increased homozygosity as compared with that obtaining in matings between unrelated animals.

INNATE—Inherited, as contrasted with being of environmental origin.

INTERCHANGE—An exchange of segments of non-homologous chromosomes. (The term "segmental interchange" was used by Belling to include crossing-over but the two are conveniently distinguished.)

INTERSEX—An organism displaying sexual characters and secondary sexual characters intermediate between male and female.

INVERSION—A re-arrangement of a group of genes in a chromosome in such a way that the order of genes is changed;—for example ABC*FED*GHI instead of the normal order, ABCDEFGHI.

K

KARYOKINESIS—Same as *mitosis.*

KARYOLYMPH—The nuclear sap—The clear fluid in which the nuclear structures (chromosomes, nucleoli, etc.) are bathed.

L

LATENT—A term applied to traits or characters whose genes exist in the germplasm of an organism, but which traits are not visible in its body.

LEPTOTENE—A term applied to the fine spireme-thread stage of the chromosomes before their union in synapsis.

LETHAL GENE—A gene which renders inviable an organism expressing it.

LINE BREEDING—A special form of inbreeding to one ancestor.

LINKAGE—Association of characters in inheritance, due to the fact that the genes determining them are physically located in the same chromosome. Such a group of linked characters is called a linkage group.

LINKAGE MAP—Chromosome map.

LOCUS—The position occupied by a gene on a chromosome, in a linkage group, or on a chromosome map.

M

MEGASPORE—The egg cell of higher plants.

MATERNAL INHERITANCE—Inheritance from mother to offspring unaffected by inheritance from the father.

MATROCLINOUS—Resembling the female parent.

MATURATION DIVISIONS—Meiosis.

MEIOSIS—The two divisions which precede the formation of gametes (or the development of a gametophyte), in which the members of each chromosome pair separate, and the chromosome number in the resulting daughter cells is reduced to half the somatic number, as distinguished from ordinary cell division (mitosis).

MENDEL'S LAW—Mendel enunciated the following basic principles of heredity: (1) That characters exhibit alternative inheritance (dominant and recessive forms); (2) that each reproductive cell receives but one member of the pair of determiners (genes) existing in the mature individual; and (3) that the reproductive cells combine at random. As a consequence of these conditions, characters appear (within the limits of chance deviation) in certain definitely predictable ratios, as 3:1; 1:2:1; 1:1, in the progeny of given hybrid matings.

MEROGONIC—From a portion of an egg.

METAPHASE—That stage of cell division in which the chromosomes are arranged in an equatorial plate.

METAXENIA—The influence of the male germ cell after fertilization on the ovary and adjacent parts.

MICROSPORE—The male plant gamete (contained in the pollen grain).

MITOGENETIC RADIATION—Radiation believed by Gurvitch and others to emanate from some growing tissues and to induce cell division in other tissues.

MITOSIS—Cell division involving the formation of chromosomes, spindle fibers, and the division of the chromosomes by a process of longitudinal splitting. Thus each of the resultant daughter cells receives a full complement of the chromosomes which existed in the original cell before division.

MODIFIER OR MODIFYING GENE—A gene which affects the expression of another gene.

MONOFACTORIAL—Controlled by a single gene difference (factor) in inheritance.

MONOHYBRID—The offspring of two parents differing in only one mendelian characteristic.

MONOPLOID—Haploid. Also sometimes used in the sense of the basic haploid chromosome number in a polyploid series. Thus in the genus Rosa, species are known in which the haploid chromosome numbers are 7, 14, 21, or 28 (the respective somatic chromosome numbers being 14, 28, 42, and 56). In this polyploid series the monoploid ("basic haploid") chromosome number is 7, but the haploid number in any given species in the series may be 7, 14, 21, etc., depending on whether the form is diploid, triploid, etc., in terms of the seven fundamental monoploid chromosomes.

MONOZYGOTIC—Originating from a single fertilized egg cell, which in the course of subsequent development has given rise to two or more individuals. Twins (or triplets, etc.) of such origin are genetically identical.

MORPHOGENESIS—The developmental history of organisms from the fertilized egg cell to the adult organism.

MOSAIC—An organism part of which is made up of tissue genetically different from the remaining part. Mosaics are produced by mutations during development, or by chromosome non-disjunction, by double fertilization of an egg, or in other ways.

MULTIPLE ALLELOMORPHISM—The existence of more than two alternative forms of a gene at the same locus. Any two members of a series of multiple allelomorphs may be allelomorphic to each other. A single individual having only the diploid number of chromosomes can bear only two members of such a series.

MULTIPLE FACTORS—Two or more pairs of factors having a similar or a supplementary or complementary cumulative effect. In a broader sense, any factors working together to produce a single result.

MUTATION—A sudden variation which is inherited, resulting from changes in the gene or genes concerned. The term is used rather indefinitely, to include "point mutations" (of a single gene) and chromosome deletions, rearrangements, duplications, chimeral changes, de Vriesian mutations, etc.

MUTUAL TRANSLOCATION—Reciprocal transfer of parts of two non-homologous chromosomes. (Essentially crossing-over between non-homologous chromosomes.)

N

NON-DISJUNCTION—(1) Failure of chromosome halves to separate in cell division, both halves going to the same daughter cell. (2) Failure of a pair of synapsed maternal and paternal chromosomes to separate at the reduction division, both chromosomes of the pair going to the same gamete.

NORMAL CURVE—A symmetrical curve of distribution of variations which are due to a multiplicity of independent causes acting equally in both directions.

NUCLEOLUS—A darkly staining body found in the nuclei of most cells. Its function is not clearly understood.

NUCLEAR SAP—See *Karyolymph*.

NUCLEUS—A highly refractive, deeply staining body of specialized protoplasm found within the cells of all organisms except bacteria. It contains the chromosomes and the karyolymph, the nucleolus, etc.

O

ONTOGENY—The developmental history of an organism, from egg (spore, bud, etc.) to adult individual.

OÖCYTE—A female reproductive cell during oögenesis, up to the time of the second division. Oöcytes are designated *primary* before the completion of the first division, then *secondary* thereafter. *Primary* have the diploid chromosome number and *secondary* the haploid chromosome number.

OÖGENESIS—The cell divisions, including meiosis, through which the reproductive cells of female organisms pass before they are matured and ready for reproduction.

OÖGONIUM—In animals,—one of the early germ cells of a female prior to the beginning of meiosis. In plants,—the organ which bears the egg cell.

ORTHOGENESIS—The doctrine that variation and evolution is determinate and purposive and follows a definite course toward a goal.

OUTCROSS—A cross to an individual not closely related.

OVUM—An egg.

P

P_1—The first parental generation—parents of a given individual (the F_1).

PANGEN—A hypothetical particle (which might be likened to a "floating gene") suggested by Darwin as an explanation of inheritance and modification of characters in his Pangenesis Hypothesis.

PARTHENOCARPY—Production of normally formed fruit with no seed or with embryoless seed. Two kinds are recognized by Winkler; stimulative, through agency of pollination, insect injury or other stimulative action; vegetative—wherein a sterile fruit develops without any other stimulation as in the navel orange.

PARTHENOGENESIS — The development of a new individual from a female germ cell without fertilization.

PARTIAL DOMINANCE—Capability of a character being produced to an intermediate degree when a mutant gene and its normal allelomorph are present in a hybrid.

PATROCLINOUS—Resembling the male parent.

PEDIGREE—A record of the ancestry of an individual.

PENTAPLOID—An organism having in its cell nuclei five times the basic haploid (monoploid) number of chromosomes.

PERICARP—The outer covering ("skin") of a seed.

PERICLINAL CHIMERA—A chimera made up of genetically different tissue arranged in layers like a hand and glove.

PHENOTYPE—The organism as exemplified by its expressed characters, as contrasted with its genetic constitution (the genotype).

PHYLOGENY—The evolutionary history of a species, genus, or type.

PLASMOSOME—A nucleolus.

PLASTID—One of several kinds of protoplasmic bodies in cells, like the chlorophyll bodies in plant cells, which are centers of chemical activity.

PLASTID INHERITANCE—Inheritance through plastids carried in the cytoplasm of the ovum. Variegation in several plants is known to be inherited in this manner.

POLAR BODY—A minute cell of which two are cast off and discarded from the animal ovum during maturation.

POLLINATION—The act of transferring pollen to the stigma of a flower.

POLYPLOID—Polyploids are forms having three or more monoploid chromosome sets in the body cells. (See *diploid*). Thus in wheat the basic chromosome number is 7. Species of wheat have either 7, 14, or 21 haploid chromosomes (14, 28, 42 chromosomes in plant cells). The species with 14 and 21 haploid chromosomes are polyploids.

POLYSOMIC—Having more than two chromosomes of one type with the remainder of the chromosome complex usually diploid.

POLYSPERMY—The entrance into the ovum of more than one sperm, whether normally or pathologically.

PREPOTENCE—The ability of an animal (usually the sire) to transmit his qualities to his offspring.

PROBABLE ERROR—See *Standard Deviation.*

PROPHASE—The stage in cell division prior to the metaphase, during which the chromosomes appear in the nucleus, following the resting stage.

PROTOPLASM—"The physical basis of life"; a chemical compound or probably an emulsion of numerous compounds. It contains proteins which differ slightly in each species of organism. It contains carbon, hydrogen, oxygen, nitrogen, sulphur and various salts, but is so complex as to defy structural analysis.

PURE LINE—A strain of organisms that is comparatively pure genetically (homozygous) because of continued inbreeding, or through other means.

Q

QUADRIVALENT—A group of four homologous chromosomes associated (often loosely), as at synapsis.

QUARTET—The four cells arising from a sporocyte.

R

RECESSIVE—See *Dominant.*

RECIPROCAL—Involving the same types of individuals, but with the sexes reversed; said of two crosses, in one of which the female possesses the same character as does the male in the other cross, and *vice versa.*

RECIPROCAL TRANSLOCATION—Mutual translocation.

RECOMBINATION—An offspring which has a combination of linked characters different from that exhibited by the parents.

REDUCTION DIVISION—The heterotypic division.

REGRESSION—The average variation of one variable for a unit variation of a correlated variable.

RELATIONSHIP (Coefficient)—A numerical statement of the average extent to which two individuals resemble each other because of genes inherited from common ancestors.

REPLICATION—Multiple repetition of an experiment under essentially similar conditions to reduce the errors due to uncontrolled factors, (soil, parasites, etc.).

REPULSION—The appearance of linked characters in different combinations than in the parents, due to crossing over.

REVERSION—Appearance of a character possessed by a remote ancestor but not by recent ones.

ROGUE—A variation from the type of a variety or standard, usually inferior. (2) To eliminate rogue plants from a seed block.

S

SECONDARY SEXUAL CHARACTER—A character dependent for its expression upon hormones of the male or female gonads, but not necessarily having any direct reproductive function.

SECTORIAL CHIMERA—A chimera in which the different tissues are arranged in sectors rather than in layers.

SEGREGATION—Separation of the genes inherited from the two parents in the formation of F_1 gametes; or (2) the random recombination of these gametes to form F_2 zygotes, resulting in the appearance of distinctly different types of offspring in F_2.

SELECTION—The choice (for perpetuation by reproduction) from a mixed population of the individuals possessing in common a certain character or a certain degree of some character. Two kinds of selection are often recognized: (1) natural selection, in which choice is made automatically by the failure to reproduce (through death or some other cause) of the individuals who are not "fit" to pass the tests of the environment (vitality, disease resistance. speed, success in mating or what not); and (2) artificial selection, in which the choice is made consciously by man, as by a plant or livestock breeder, for characters of value to man.

SELFED—Self-pollinated.

SEX-CHROMOSOMES — Chromosomes which are particularly connected with the determination of sex. In mammals and flies the females have two *X*-chromosomes and the males one *X* and one *Y*. The *X*-chromosomes carry genes of major significance in the determination of femaleness characteristics. The *Y*-chromosome often carries only sex genes. The *X* and *Y* chromosomes are often visibly different in size or shape. In birds, butterflies, moths, and some fishes

the male has two *Y*-chromosomes and the female one *X* and one *Y*. To distinguish the two types of sex-inheritance the *YY*-chromosomes in this latter case are sometimes symbolized as *ZZ*, and the *XY* as *ZW*.

SEX-LIMITED—Expression of a character in only one sex. Examples: milk production, horns in Rambouillet sheep, egg production.

SEX-LINKAGE—Association of a hereditary character with sex, in such wise that (in the case of a recessive character such as color-blindness) it crosses from one sex to the other in successive generations (criss-cross inheritance), due to the fact that its chromosome is the mate of an empty ("dummy") chromosome for the gene in question.

SIBLING—One of two or more children of the same parents, but not of the same birth. SIB.—Sibling.

SKEW CURVE—An asymmetrical variation curve, in contrast to the symmetrical Gaussian curve.

SOMATIC—Referring to body tissues; having two sets of chromosomes, one set normally coming from the female parent and one from the male; as contrasted with mature germ cells having a single set of chromosomes.

SOMATIC MUTATION—A mutation in a somatic cell, resulting in a chimeral individual with respect to the mutant character.

SPERM—A mature male germ cell—the spermatozoön or spermatosome.

SPERMATID—One of the two cells formed by the second division in spermatogenesis. By transformation in shape the spermatids become mature spermatozoa.

SPERMATOCYTE—A male reproductive cell during spermatogenesis up to the time of the second division. Spermatocytes are designated *primary* before and during the first meiotic division, *secondary* thereafter.

SPERMATOGENESIS—The formation and maturation of the germ cells of the male or in the testis of an hermaphrodite animal.

SPERMATOGONIA—Primordial male germ cells, immediately preceding primary spermatocytes.

SPINDLE—A group of structures, observed in fixed cytological preparations, resembling threads, in the form of a spindle, formed during mitosis.

SPIREME—Chromosomes in the slender, thread-like stage characteristic of the early prophase of cell division.

SPOROCYTE—A spore mother cell of plants.

SPOROPHYTE—Plants and lower animals exhibit various combinations of alternation of generations. A diploid, spore-forming generation (the sporophyte), produces spores which give rise asexually to an altogether different form, the gametophyte. These gametophytes produce sex-cells which unite (fertilization) to initiate the development of a new sporophyte. In the higher plants the "plant" itself is the sporophyte and the gametophytes are rudimentary, having a brief but important part in the reproductive cycle—the pollen grain and its later development into the pollen tube, representing the male gametophyte generation.

SPORT—An abrupt deviation from type. An obsolescent term for mutation.

STANDARD DEVIATION (designated *Sigma*, σ)—A statistical constant used as a measure of dispersion. In a distribution following the normal law, it is the square root of the mean of the squares of the individual deviations from the mean of the series. The *probable error*, or *probable deviation*, in a normal distribution equals .6745 σ. A range of twice the probable error, centering at the mean, will include 50 per cent of all the observations in such a series.

SUPER-FEMALE—A female (Drosophila) whose cells carry one or more extra X-chromosomes (*XXX* instead of the normal *XX*).

SYNAPSIS—The conjugation or union in pairs of homologous chromosomes, respectively of maternal and paternal origin, to form bivalents; the primary step in meiosis.

SYNDACTLY—The fusion of fingers and toes.

SYNDROME—A group of symptoms occurring together.

SYNGAMY—Union of the gametes in fertilization or conjugation.

SYNIZESIS—Synapsis.

T

TELEGONY—An alleged effect of a previous sire on later progeny of the same dam by another sire. A quaint superstition which dies hard.

TELOPHASE—The closing phase of mitosis, during which the daughter-nuclei are formed and the mother cell usually divides.

TETRAD—The quadruple group of chromatids formed by the association of bivalent chromosomes during meiosis.

TEST CROSS—A backcross of a diheterozygote to a double recessive, to test linkage.

TETRAPLOID—An organism whose cells contain four haploid (monoploid) sets of chromosomes.

TETRASOMIC—An organism whose cells contain four chromosomes of one type, the rest of the chromosome complement being diploid. (Chromosome formula: $2n + 2$.) See *trisomic*.

TRAIT—A term loosely used by geneticists as a synonym of "character."

TRANSGRESSIVE SEGREGATION—The appearance in the F_2 (or later) generation of a cross of individuals showing a more extreme development of a character than either parent. Assumed to be due to cumulative and complementary effects of genes contributed by the parents of the original hybrid.

TRANSLOCATION—Attachment of a fragment of one chromosome to a non-homologous chromosome, resulting in a new arrangement of genes.

TRIHYBRID—A hybrid heterozygous with respect to three pairs of genes. A triheterozygote.

TRIPLOID—An organism characterized by having three times the haploid (or monoploid) chromosome number.

TRISOMIC—An otherwise diploid organism which has an extra chromosome of one pair. (Chromosome formula: $2n + 1$.)

TWO-FACTOR INHERITANCE—Some characters depend for their development on genes situated at two loci. Various combinations of allelomorphs of these two genes may be necessary in a given instance to produce a specific character. See *Complementary Genes.*

U

UNIT CHARACTER—A hereditary trait that behaves as a unit in transmission, being capable of inheritance independently of other unit characters and determined by the allelomorphs of a single gene. Example: green and yellow seed color in peas.

UNIVALENT—A chromosome unpaired at meiosis.

V

VARIATION—In biology, the occurrence of differences among the individuals of the same species.

VARIETY—In taxonomy, a division of a species; a group of individuals within a species which differ in some minor respect from the rest of the species. Agronomic varieties are the product of human selection, and differ in characters of economic importance.

VEGETATIVE REPRODUCTION—Reproduction by buds, grafts, cuttings, etc., in which sex cells are not involved.

W

W-CHROMOSOME—See *Sex-chromosomes.*

X-Y-Z

X- and *Y*-CHROMOSOMES—See *Sex-chromosomes.*

XENIA—Immediate effect of pollen on the endosperm, due to the phenomenon of double fertilization in the seed plants.

XENOPLASTIC GRAFT—A heteroplastic graft that "takes" and continues to develop in its new site (most heteroplastic grafts are short lived).

Z-CHROMOSOME—See Sex-Chromosomes.

ZOOSPORES—Spores possessing the power of independent motion.

ZYGOTE—The cell produced by the union of two cells (gametes) in reproduction; also the individual developing from such a combined cell.

ZYGOTENE—A stage in meiosis, preceding synezisis (synapsis), during which the chromosome homologues begin to pair.

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